February 2000

MCKENZIE RIVER SUBBASIN ASSESSMENT

Technical Report 2000

DOE/BP-23129-1

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do not necessarily represent the views of BPA.

This document should be cited as follows:

Runyon, John - Pacific Wildlife Research, Inc., McKenzie River Subbasin Assessment - Technical Report February 2000, Report to Bonneville Power Administration, Contract No. 2000AC23129, Project No. 200003000, 206 electronic pages (BPA Report DOE/BP-23129-1)

This report and other BPA Fish and Wildlife Publications are available on the Internet at:

http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi

For other information on electronic documents or other printed media, contact or write to:

Bonneville Power Administration
Environment, Fish and Wildlife Division
P.O. Box 3621
905 N.E. 11th Avenue
Portland, OR 97208-3621

Please include title, author, and DOE/BP number in the request.

McKenzie River Subbasin Assessment

Technical Report

February 2000

Prepared for the McKenzie Watershed Council

Prepared By:
Alsea Geospatial, Inc.
Hardin-Davis, Inc.
Pacific Wildlife Research, Inc.
WaterWork Consulting

McKenzie River Subbasin Assessment

Guide to the Technical Report

Part 1

Part 2

Part 3

The McKenzie River Subbasin Assessment was funded by grants from the Bonneville Power Administration and the U.S. Forest Service.

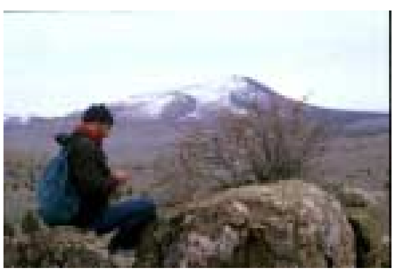
McKenzie Watershed Assessment Team Members

John Runyon is project manager for the McKenzie Watershed Council. John was responsible for coordinating the subbasin assessment process, facilitating the steering committee, and riding herd over the consultants.

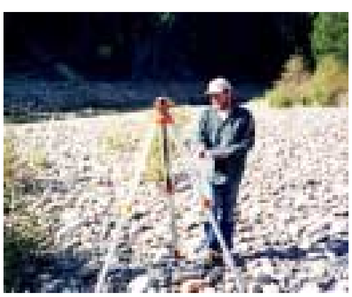
No photo available yet.

Chip Andrus is the lead analyst at WaterWork Consulting. For this report Chip analyzed the current river conditions, classified streamside land use and vegetation, and contributed many pages of text.

John Gabriel is the general manager and a GIS analyst at Alsea Geospatial, Inc. He has over ten years experience conducting GIS analysis and managing complex ecological studies. John's extra time is spent with his family, swimming, or biking around Corvallis.



Dave Vesely is a forest ecologist and president of Pacific Wildlife Research. Dave authored the report sections on the pond turtle and priority vegetation types. Dave used to race road bikes, climb ice, and make sculpture before starting a consulting firm.



Tim Hardin holds a Ph.D. in Fishery Biology from Colorado State University. Since 1982 he has been the senior fishery biologist at Hardin-Davis, Inc. The firm has conducted aquatic habitat studies similar to the one for this report throughout the western U.S.

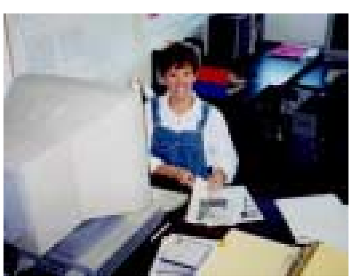
Rachel Schwindt is a GIS analyst with Alsea Geospatial, Inc. She was the lead spatial analyst for this project and spent many hours in digitizing, analysis, and map production. In her spare time, Rachel enjoys cycling, kayaking, and gardening.

Dave Callery works as a geographer/biologist for Hardin-Davis, Inc. where he often researches & writes reports of this nature. Before earning an M.S. in Physical Geography at University of Wisconsin-Madison, Dave worked as a biologist for the USFS and the EPA, and spent several years working in environmental/outdoor education.

Dave Chiller is a research biologist at Pacific Wildlife Research. For this report, Chiller conducted the aerial reconnaissance for oak woodlands, assisted with the turtle habitat model, and was principal GIS analyst at PWRI. Chiller gets an early start on weekends (Thursday night) so he can go surfing and play drums with various local bands.

No photo available yet.

Jennifer Weikel is a wildlife ecologist at Pacific Wildlife Research. Jennifer authored the sections on bird populations and habitats for this report. Jennifer spends weekends riding dressage on her horse Wiley. Jennifer's husband, Jim, is a Benton County deputy sheriff that spends his weekends trying to control Chiller's musician friends.



Lael Rogan is a GIS analyst with Alsea Geospatial, Inc. In addition to doing a lot of the digitizing for this study, she also made maps. Lael received her Master's degree from OSU and enjoys running and swimming in her off-duty time.

In addition, Michelle Bridge, AnnaJo Cheney, Ryan Emig, Mindy Fredericksen, Rebecca Miller, Julie Moore, Donna Sharp, and Jon Voltz contributed historical information as a part of their FW 441 class at OSU.

Part 1: Introduction

Detailed Table of Contents

High Priority Action Items for Conservation, Restoration, and Monitoring

Our analysis indicates that aquatic and wildlife habitat in the McKenzie River subbasin is relatively good yet habitat quality falls short of historical conditions. High quality habitat currently exists at many locations along the McKenzie River. This assessment concluded, however, that the river's current condition, combined with existing management and regulations, does not ensure conservation or restoration of high quality habitat in the long term.

Significant short-term improvements in aquatic and wildlife habitat are not likely to happen through regulatory action. Current regulations rarely address remedies for past actions. Furthermore, regulations and the necessary enforcement can fall short of attaining conservation goals. Regulations are most effective in ensuring that habitat quality trends improve over the long period.

We see a strong need for the McKenzie Watershed Council to embrace a proactive approach to habitat conservation and restoration in order to ensure significant short- and long-term improvements in habitat quality. We recommend that these voluntary activities for the McKenzie River subbasin be based on educational outreach, conservation actions, restoration actions, institutional change, and monitoring. The most important action items are summarized on the next several pages. Following the action items are three figures highlighting key conservation areas for the lower McKenzie River subbasin.

Education

1. **Educate landowners and the general community about the need to give the river room to roam.** When free of riverbank development, riprap, and diking, a river has the opportunity to meander and create critical habitat features such as gravel bars, side channels, ponds, and islands. Siting houses and other infrastructure a distance from the river provides space for these important habitats. Currently, one-third of riverfront parcels in the study area are vacant. Many of these sites will be developed and some existing riverfront houses will be torn down and rebuilt during the next few decades. Educating landowners about the value of setting structures back from the river may pay dividends in both better river protection and less flood damage.

2. **Educate landowners about the importance of maintaining natural riparian vegetation along the river for the benefit of fish and wildlife**. Older trees are now scarce along the McKenzie River. When natural vegetation of various types and age classes occurs along a river, more species of birds and other animals can exist along the river. Older trees are particularly important because they result in useful snags and, when they fall over, result in large wood for riparian areas and the channel.

3. **Increase awareness of the scarcity and decline of oak woodlands and of the unique role oak trees have in supporting certain species of wildlife.** Compared to historical conditions, oak woodlands are rare in the lower McKenzie River subbasin.

4. **Educate landowners and the general community about the need to leave large wood in the river channel and in the floodplain to help maintain channel complexity, improve fish habitat, and enhance riparian conditions.** Currently, large wood in the channel and on the floodplain is very scarce due, in part, to intentional removal (firewood cutting, boat safety).

<u>Conservation</u>

5. **Conserve river segments that could and currently do provide good off-channel habitat and/or older forests along the river, gravel bars, side channels, islands, ponds, and willows.** Segments with the best remaining habitat include the McKenzie River between Hendricks and Hayden bridges and the Willamette River between the old and new McKenzie River confluences. Other high-quality reaches are scattered throughout the study area but occur mostly downstream from Leaburg Lake. Segments with these features usually provide preferred habitat for multiple organisms including fish, pond turtles, and birds.

6. **Conserve quality riparian woodlands with large trees for bird habitat. The highest quality habitat includes large tracts (greater than 50 acres) containing large-diameter (greater than 22 inches) cottonwoods, and an understory of ash or willow rather than introduced species.** Most of the remaining large patches of riparian woodlands are located in confluence area of the McKenzie and Willamette rivers, around the edges of the Springfield, and the lower portions of the Cedar Creek and Mohawk River watersheds.

7. **Conserve remaining oak woodland patches.** Oak woodlands are rare on the current landscape; most of the remaining large patches are located in the lower subbasin, primarily in the Mohawk River, Cedar Creek and Camp Creek watersheds.

8. **Conserve wetlands in the subbasin.** High priority wetland conservation areas are located in the confluence area of the McKenzie and Willamette rivers, and the lower portions of the Cedar Creek and Mohawk River watersheds. These portions of the study area once had the most wetlands.

Restoration

9. **Restore channel complexity in areas where human influences (reduced peak flows and channelization) have caused the river to become simplified.** Excavating the upstream ends of plugged side channels, excavating alcoves and ponds, or removing dikes and riprap can help the river occupy features that provide special habitat features for fish and wildlife. These deliberate actions are needed to restore channel complexity since peak flow dampening at the reservoirs prevents the river from doing this on its own. Channel complexity restoration options are best downstream from the I-5 Bridge in the confluence area of the McKenzie and Willamette rivers and at other locations that were historically complex such as the McKenzie River between Hendricks Bridge and Hayden Bridge.

10. **Remove invasive plants such as blackberry, reed canarygrass, and Scotch broom in riparian areas and replant with native vegetation.** Riparian areas free of invasive plants that restrict regeneration of native trees are more capable of producing habitat features important to fish and wildlife.

11. **Restore wetlands in subbasin.** High priority restoration areas include the confluence area of the McKenzie and Willamette rivers, and the lower portions of the Cedar Creek and Mohawk River watersheds, and other areas that once had important wetlands.

Institutional Change

12. **Encourage the Oregon Department of Fish and Wildlife (ODFW) to limit hatchery introductions throughout the basin.** Fish hatchery operations currently produce fish (spring chinook, steelhead, rainbow trout, and brook trout) in the McKenzie River subbasin that have potential to compete with wild native stocks and lead to the decline of wild stocks. Spring chinook is a federally listed species that faces the threat of gene dilution due to interactions with hatchery spring chinook. Bull trout is also a federally listed species and faces the threat of hybridization with introduced brook trout.

13. **Encourage ODFW to improve the accuracy of their wild chinook population assessment by eliminating the practice of introducing unmarked hatchery chinook fry into Cougar Reservoir.**

14. **Encourage the city of Springfield and Lane County to revise zoning and land use rules so that harmful development does not occur in floodplains and riparian areas.** Harmful development includes that which limits the river's meander pattern or cuts it off from its side channels, alcoves, and ponds. It also includes major disturbances of natural vegetation.

15. **Encourage the city of Springfield and Lane County to identify and eliminate sources of bacteria and fecal river contamination (e.g., failing septic systems and stormwater pipes), in Cedar Creek, Mohawk River, and the lower McKenzie River.**

16. **Encourage the US Army Corps of Engineers to seek funding to modify Blue River Dam, in order to repair the problem of warm water releases in late summer and fall from Blue River Reservoir.** The artificially warm water hinders spring chinook egg development.

17. **Encourage the US Army Corps of Engineers to transport logs trapped at the reservoirs to reaches below the dams so that the logs can continue to benefit fish habitat in downstream reaches.**

Monitoring

18. **Survey western pond turtles and their remaining habitat in the lower McKenzie River subbasin.** Little is currently known about western pond turtle abundance, how well they are reproducing, or habitat quality. Most potential western pond turtle habitat is on private land and so coordination with landowners would be needed.

19. **Identify additional tributary streams that are abnormally warm in the summer.** A subset of tributaries flowing through forest land have been measured, but few have been measured once they enter non-forest land. The survey should also identify causes and locations of abnormal warming.

20. **Conduct an investigation into why lower McKenzie River tributaries have low densities of insects that are the preferred food for salmonids.** Also, determine aquatic insect abundance in the McKenzie River main channel throughout the study area.

Part I: Introduction

This document details the findings of the McKenzie River Subbasin Assessment team. The goal of the subbasin assessment is to provide an ecological assessment of the McKenzie River Floodplain, identification of conservation and restoration opportunities, and discussion of the influence of some upstream actions and processes. This Technical Report can be viewed in conjunction with the McKenzie River Subbasin Summary or as a stand-alone document. The purpose of the technical report is to detail the methodology and findings of the consulting team that the observations and recommendations in the summary document are based on. This part, Part I, provides an introduction to the subbasin and a general overview. Part II details the specific findings of the science team. Part III provides an explanation and examples of how to use the data that has been developed through this assessment to aid in prioritizing restoration activities. Part III also includes the literature cited and appendicies.

Either the summary report or this report can also be viewed on the McKenzie Watershed Council's website, listed below.

http://www.mckenziewatershedcouncil.org/library.html

A CD-ROM for computers is also available; the CD-ROM has the reports as well as the GIS datasets (Geographic Information System), for those who want to work with the information. To obtain the CD-ROM, call Alsea Geospatial, Inc., at 541-754-5034, or go to Alsea Geospatial's website, listed below.

http://www.alseageo.com

Subbasin Overview

The McKenzie River watershed extends from the ridge of the central Cascade Mountains to the floor of the Willamette Valley, where the McKenzie River joins the Willamette River (Appendix 4, Figure 1). The river and State Highway 126 pass through several small towns including Nimrod, Vida, Leaburg, and Walterville. The river flows from one of the most remote and rugged parts of the Cascades to Oregon's second largest metropolitan area—Eugene-Springfield (Appendix 4, Figure 2). Main tributaries include the Mohawk River, Blue River, South Fork of the McKenzie, Gate Creek, Quartz Creek, Horse Creek, and Lost Creek.

People have lived in the McKenzie River watershed for thousands of years. European-Americans began to settle in the watershed about 150 years ago. The watershed provides a rich variety of resources and recreational opportunities. People's uses of the watershed's resources, combined with the population growth in the cities, have altered the ecosystem significantly. In 1944 the river interacted with its floodplain through a series of side channels, alcoves, islands, and ponds, providing an abundance of diverse habitats. Aerial photographs from 1910 show an even more complicated river system. Today the river is confined to a narrow course through this same area, with riprapped banks in many places (Appendix 4, Figure 3). A timeline of significant events affecting the watershed is included in Appendix 1.

Study Plan

The McKenzie Watershed Council directed the consultants to concentrate their resources on a detailed analysis of the area over which the Council has the greatest influence. Therefore this study is concerned primarily with the lower McKenzie River subbasin and floodplain—the study area. The Technical Report places the lower subbasin in a broader watershed context, while still emphasizing watershed issues.

The study area was divided into 37 river reaches, or segments, defined by changes in geomorphology, land use, tributary junctions, and/or cultural features (e.g., Leaburg Dam). Reach numbering starts at the historical confluence of the McKenzie and Willamette rivers (Reach 1), and goes upstream. The present-day confluence of the McKenzie and Willamette rivers defines the boundary between Reaches 2 and 3. Farther upstream, Leaburg Dam defines the boundary between Reaches 26 and 27; and finally, Reach 37 contains the confluence of Quartz Creek and the McKenzie River. The reaches are further subdivided into north and south bank (e.g., Reach 10N and 10S). Current land uses, such as forest, farms, or residential, were mapped within 0.5 miles of the river, using April 2000 aerial photographs. Historical photographs were used for land use delineation within 1,000 feet of the river. In this document, “historical” means circa 1944, the year when the first series of aerial photographs was taken of the river. The 1944 aerial photographs go upstream only to Leaburg Lake.

Land Ownership Patterns

In the upper subbasin, large contiguous blocks of federal land are managed by the USDA Forest Service. Below Blue River, federal and private forest lands are mixed in a checkerboard ownership pattern, with federal lands managed by the Bureau of Land Management (BLM), and the private forest lands owned and managed by forest industry companies (Appendix 4, Figure 4). Almost all of the floodplain is private land. Table 1 shows land ownership in the basin, in acres and as a percent of the total, as well as ownership within the floodplain (defined as the area within 0.5 miles of the river channel) of the McKenzie River.

Table 1. Ownership in the McKenzie. Source: Lane Council of Governments, Alsea Geospatial.

Ownership	**Subbasin acres (percent)**	**Floodplain acres (percent)**
Military & US Army Corps of Engineers	4,322 (< 1%)	0 (0%)
Private	266,677 (31%)	37,842 (91%)
State Lands	736 (< 1%)	0 (0%)
USFS National Forest	533,343 (62%)	493 (1%)
Bureau of Land Management/ Oregon and California Lands	52,296 (6%)	3,068 (7%)
Total	**857,364**	**41,403**

Land use allocations & zoning

Basin wide, forestry is the dominant land use. However, in the ecologically important floodplain of the lower McKenzie, agriculture, commercial, and residential development is dominant. Lane County zoning patterns as well as real estate values emphasize residential and commercial concentration in the valley floor area, in part due to the existing infrastructure to support such development as well as its high desirability. Approximately 4,313 acres within the floodplain are either developed or available for future development. Some of the impacts of residential development in the floodplain are in the technical report.

Land Management Regulations

The regulations for land and water management vary widely within the McKenzie River subbasin, by land ownership and type of land use. The federal, state, county, and city agencies involved in the basin are described below.

- **The USDA Forest Service and Bureau of Land Management** are the two federal agencies that manage federal forest lands in the subbasin. All federal forest land in the McKenzie River subbasin is managed according to the standards and guidelines prescribed in the *Northwest Forest Plan* and the *Record of Decision* (USDA Forest Service et al., 1994a and b). These documents prescribe standards for timber harvest, road building and maintenance, forest regeneration, and many other activities on federal lands, along with a process for developing site-specific prescriptions. The *Record of Decision* designated four areas as Key Watersheds: Upper McKenzie River/Boulder, Horse Creek, South Fork McKenzie River, and Marten/Bear (Figure 7). A Key Watershed designation indicates that a watershed analysis must be completed prior to activities and that there be no net increase in roads. Most federal land is upstream from Leaburg Dam.

- **The Oregon Department of Forestry** regulates timber harvest and management on privately owned forest lands. The agency's Oregon Forest Practices Rules prescribe acceptable logging practices, road building and maintenance standards, tree planting requirements, and requirements for leaving trees along streams. Most private forest lands in the watershed are located in the hills downstream from Leaburg Dam.
- **Agricultural practices** are addressed by a farming management plan for the watershed, developed in compliance with Senate Bill 1010. Senate Bill 1010 established a process for developing local, voluntary plans to end agricultural practices that are harmful to streams and the land. The plan for the McKenzie River subbasin is scheduled to be completed in 2002. In the McKenzie watershed, agricultural activities are concentrated on the valley floors of the McKenzie River, Mohawk River, and Camp Creek. Major crops include grass seed, filberts, and pasture.
- **Lane County** develops regulations that govern other private land use outside the urban growth boundaries of Eugene and Springfield. Lane County has developed riparian rules that are currently under review. These rules were designed to protect natural vegetation and minimize disturbance near fish-bearing streams. The county also administers land use planning and building permits outside urban growth boundaries. Springfield and Eugene regulate land use within their respective urban growth boundaries. The two cities are currently evaluating their influence on fish in the McKenzie River, Willamette River, and tributaries.
- **The Oregon Department of Environmental Quality (DEQ)** regulates point source discharges into the McKenzie River and its tributaries, as mandated by the Clean Water Act. Any business or activity that discharges water into these waterways must get a permit from DEQ, which regulates the types and amounts of pollutants allowed in the discharge. The DEQ also establishes TMDL (total maximum daily load) standards for rivers in Oregon. TMDL is the maximum amount of pollutants allowed to enter a river; DEQ then allocates the total pollution load among the different sources, and sets goals to reduce the discharges. DEQ is scheduled to establish a TMDL standard for temperature in the McKenzie River subbasin, by 2002. This new standard will establish a maximum allowable temperature for water discharged into the river, in addition to the permits' existing standards on pollutants.
- **The Oregon Water Resources Department** issues permits for water withdrawals from the McKenzie River and its tributaries. Currently, if all McKenzie River permit holders were to use their right to withdraw water at the same time, the demand would exceed the river's natural summer flows in most years. This has not been a problem only because the US Army Corps of Engineers releases enough water from Cougar and Blue River reservoirs in the summer to keep river flows higher than the natural level would be. The Oregon Department of Fish and Wildlife has obtained instream water rights for most of the McKenzie River basin, in order to help guarantee enough water flow for fish. But these instream rights were obtained in the late 1980s so they are junior to most other water rights. Under Oregon law, water rights are allocated by seniority (original date) of the right. Senior water rights

holders can use their allowed amount of water before—and to the exclusion of, if water is limited—junior water rights holders.

- **The Federal Energy Regulatory Commission (FERC)** licenses non-federal dams and hydropower facilities. The FERC-licensed dams in the McKenzie River subbasin are the Walterville project, Leaburg project, and Carmen-Smith Reservoir project, all of which are operated by the Eugene Water and Electric Board (EWEB). The Cougar and Blue River dams, which are owned and operated by the US Army Corps of Engineers, are not subject to FERC review. However, operations at Cougar and Blue River dams are subject to the Clean Water Act and the Endangered Species Act. Funding must be obtained from Congress in order to make any major changes to the two federal dams for the benefit of fish. For example, currently a water temperature control system is being installed at Cougar Dam, so that water releases from the reservoir are the same temperature that the water in the river would have been before the dam changed water flows and water temperatures. Congressional funding was granted for the Cougar project but no funding has yet been provided to remedy the water temperature problem at Blue River Dam.

- **The US Army Corps of Engineers** regulates any proposed alterations to river and stream channels and the fill or removal of materials from a channel (or wetland), under the authority of the Clean Water Act. This responsibility is generally delegated to the Oregon Division of State Lands, which reviews applications and issues permits. A permit to alter a waterway channel must also be accompanied by a water quality certification by the Oregon Department of Environmental Quality.

- **The Oregon Department of Geology and Mineral Industries** regulates gravel mining operations that occur next to the lower McKenzie River. In addition, the Oregon Department of Environmental Quality requires permits for discharging gravel pit water into the river. The Oregon Division of State Lands would regulate any gravel mining that occurred in the current river channel, but currently there are no gravel mining operations within the McKenzie River. The US Army Corps of Engineers requires permits for building dikes and constructing riprap, as well as for gravel removal.

- **The federal Endangered Species Act** lists two fish species in the McKenzie River subbasin, bull trout and spring chinook salmon, as threatened species. Bull trout live their entire lives in freshwater, and therefore the US Fish and Wildlife Service is responsible for bull trout recovery. Spring chinook salmon spend part of their lives in the ocean and are classified as marine species; this classification means that the National Marine Fisheries Service is responsible for their recovery. These two federal agencies rely on state and other federal agencies (USDA Forest Service, Bureau of Land Management, US Army Corps of Engineers) to implement recovery actions, and also they often require agencies and individuals to consult directly with them. The Oregon Department of Fish and Wildlife (ODFW) lists the western pond turtle in the “critical” category of the sensitive species list.

Part 2: Past and Current Watershed Conditions

Detailed Table of Contents

Part II: Past and Current Watershed Conditions

Aquatic Ecosystem

The aquatic ecosystem in the McKenzie River basin is defined at a fundamental level by the geology that underlies the basin and subsequent geomorphic events. The upper portion of the McKenzie River watershed (high Cascade Mountains) is derived from relatively young volcanic material originating 12,000 to 9 million years ago and heavily influenced by later glaciation. The lower watershed (the "old Cascade Mountains" west of Smith River and north of Belknap Springs) is much older volcanic rock and glaciation influences are relatively minor. The basin experienced extensive uplift and faulting during the last 3 to 10 million years ago further fracturing the underlying bedrock (USFS 1995).

Massive ice fields formed in the Cascade Mountains and slowly moved down the valleys. There were three major ice-forming events that influenced the basin with the first starting 1.6 million years ago and the last ending 12,000 years ago. Melting of this ice cap was usually gradual but sometimes included massive floods caused by temporary lakes breaching ice dams. Glacial outwash filled the valley with gravel and cobbles and often led to major channel changes. (USFS,1995).

The McKenzie River valley changes abruptly downstream of Hendricks Bridge where an extensive terrace dominates the valley. The terrace is capped by a veneer (10-30 feet deep) of fine deposits resulting from a series of catastrophic torrents caused by breaching of huge glacier-formed dams in Idaho. These floodwaters raged down the Columbia River, backed into the Willamette valley, and released their load of silt (Alt and Hyndman 1978). Since the last of these catastrophic floods, the McKenzie River has cut down through the deposits to the underlying gravel and cobble.

A considerable amount of runoff in the upper McKenzie River flows beneath the surface due to the highly porous and fractured volcanic rock and glacial deposits. This delays the time it takes for rain and melting snow to reach stream and river channels. Also, it keeps runoff from picking up sediment. The result is dampened peak flows and clear water for McKenzie River basin streams and rivers. This also happens in the lower McKenzie River, but to a lesser extent, since the rock is less fractured and porous glacial deposits are limited. Throughout the basin, some of the runoff travels slowly through the porous and fractured geology of the McKenzie River basin, taking months to reach the river, and resulting in significant amounts of cool water added to the river during the summer.

The geomorphology of the study area (Quartz Creek confluence to the confluence of the Willamette River with the old McKenzie River channel) changes considerably in a downstream direction.

- From Quartz Creek to Leaburg Lake, the river is tightly bound by steep hillslopes. Some old riverside terraces exist but most are too high for the river to access. The river bed in this upstream segment has a high gradient and is composed mostly of bedrock, boulders, and cobbles. Gravel bars occur mostly at the mouths of major tributaries.

- Downstream of Leaburg Lake the valley widens slightly but the river is still bound by steep slopes on the south side. Bedrock gives way to more boulders and cobbles, although the channel gradient is still relatively steep.

- Between Hendricks Bridge and Hayden Bridge the valley opens up and the channel gradient is low. The river meanders widely resulting in many side channels and other off-channel features. Here, the river terraces are low, flood-prone, and the river substrate is finer. Areas of extensive bedload deposition occur immediately upstream of bedrock intrusions in the channel (e.g. immediately upstream of Hayden Bridge).

- Downstream of Hayden Bridge, the McKenzie River meanders to the north side of the valley and again becomes entrenched as it flows adjacent to steep rock slopes of the Coburg Hills.

- Finally, downstream of Hwy I-5, the river enters what once was an extensive delta of multiple channels, ponds, and islands. The area is much different now due channelization and diking that was conducted to accommodate gravel extraction operations.

- Currently, the McKenzie River enters the Willamette River about 3 miles upstream of where it did prior to 1965. The old channel now has flow only during high water. The segment of the Willamette River between the current and old channel contains many islands, side channels, alcoves, and ponds. Currently, little development occurs next to this portion of the river.

Changes to the McKenzie River since European settlement that have potential to influence ecological functions in the river include:

- Large logs in the channel, as well as old streamside trees that are a source of that wood, were once abundant but are now scarce. Logs from portions of the upper McKenzie River that would normally float to the lower river are now intercepted by two large upstream reservoirs, Blue River and Cougar.

- The two large reservoirs dampen peak flows and provide a level of flood protection to downstream towns and cities along the McKenzie River and Willamette River. Also, water is released from the reservoirs in the summer to improve downstream fish conditions, dilute pollution, and provide water for irrigation and for industrial and municipal uses.

- At two locations within the study area, a portion of the McKenzie River is diverted into canals, used to make power, and then returned to the river. This partial dewatering of the McKenzie River affects 5.9 miles downstream of Leaburg Lake and 7.3 miles downstream of Deerhorn.

- Some stretches of McKenzie River have been channelized and/or riprapped to keep the river from changing it location.

The quality of water in the lower McKenzie River is high and of special importance to the City of Eugene, which supplies over 200,000 residents with water. Water is extracted low in the watershed and so land use throughout most of the basin has the potential of influencing the city's water. The quality of raw water influences the city's ability to provide safe and palatable drinking water. Potential sources of water contamination in the basin includes; failing septic systems, stormwater from cities, industrial point sources, cattle, wildlife, and spillage of toxic materials when cars or trucks are involved in accidents near streams and rivers.

Salmon and trout are considered by many to be more numerous in the McKenzie River than in any other Willamette River basin. Potential contributing factors to this high salmonid abundance include; cool summer water temperature, lack of pollution, relatively high flows in the summer, a rocky substrate, the existence of zones where the channel is low-gradient and meanders frequently, and the establishment of strict fishing regulations that are enforced. Potential negative factors that threaten to diminish salmonid abundance in the future include increased riverfront development, further channelization, expansion of unmitigated stormwater systems, and further simplification of the river channel. In the following sections these and other contributing factors are discussed.

Reaches downstream of Hendricks Bridge have more potential than upstream reaches to provide high quality rearing habitat for fish and wildlife. Characteristics of this area include a low channel gradient, a wide flood plain, high levels of channel complexity, and relatively low riverfront development.

In the following sections we discuss various aspects of fish habitat quality and water quality, how they have changed since European settlement and their likely future status.

Flow regime

Two large flood control dams, Cougar Dam finished in 1963 and Blue River Dam finished in 1968, have altered the magnitude and timing of flows in the lower McKenzie River. Peak flows have been dampened with the annual peak flows (instantaneous maximums) following construction of dams averaging only 59% of the values prior to the dams (Figure 2-1). Flows greater than that which occurred in February, 1996, (30,900 cfs) occurred about 4 times per decade prior to dam construction. The 1996 flood was the highest flow on record for the 31-year period following construction of the dams.

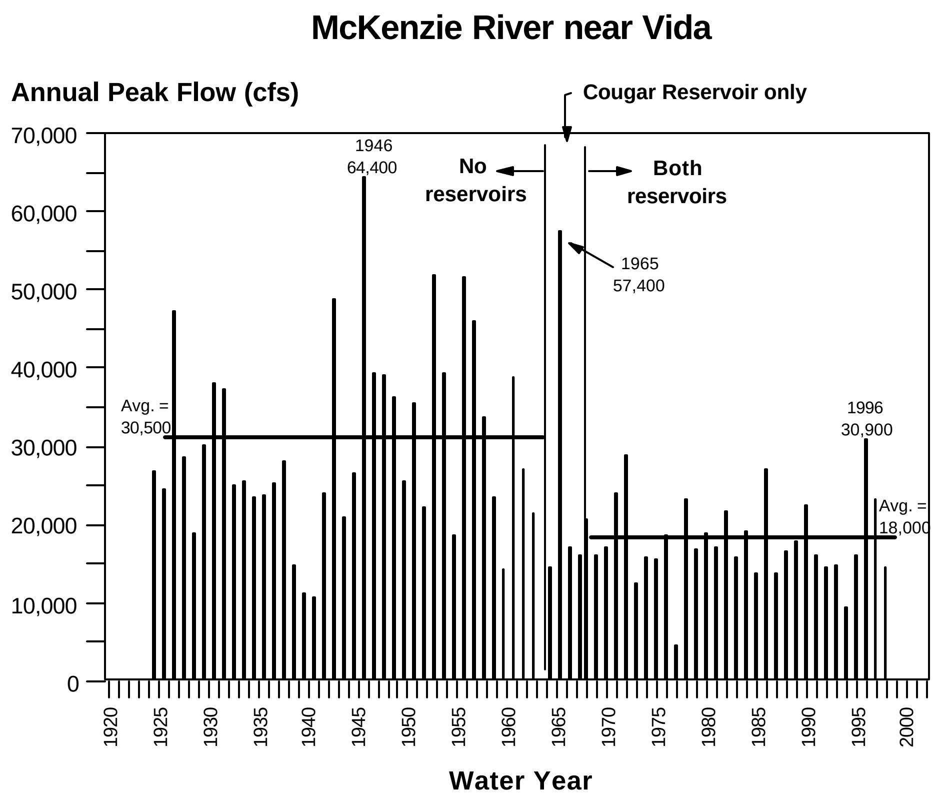


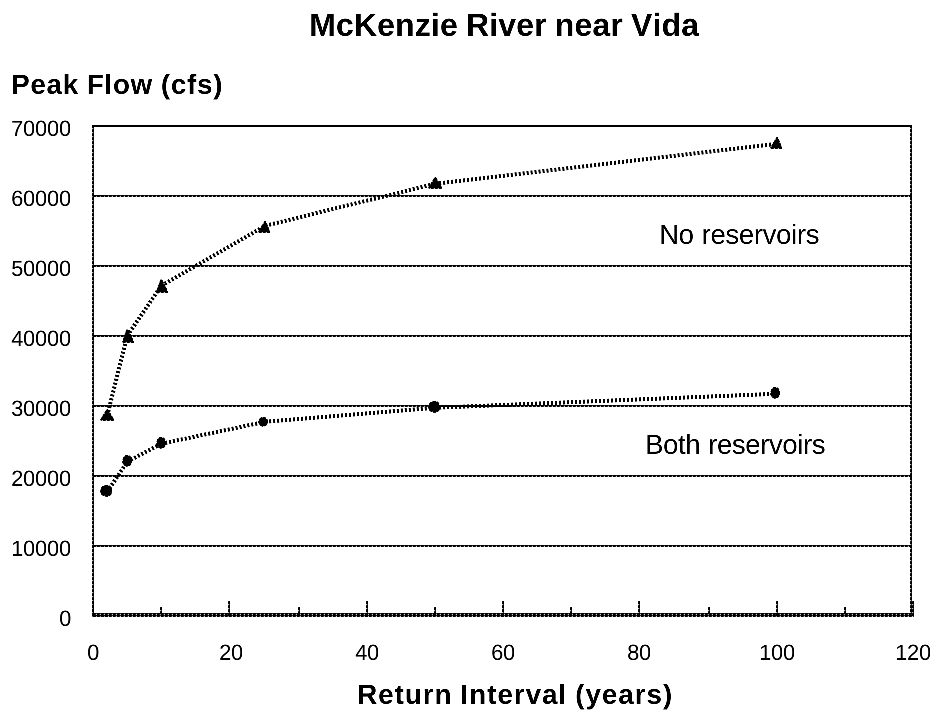
Figure 2-1. Annual peak flows for the McKenzie River near Vida (by water year) before and after dam construction.

The December 1964 flood was the second highest flow on record, even though Cougar Dam was already operating. Cougar Dam has about twice the water capacity of Blue River Dam, so the December, 1964, peak flow would have been considerable even if Blue River had been operating. This points to the limitations of dams to hold back extraordinary peak flows and the vulnerability of houses and other buildings located in the river's old flood plain.

The reservoir dampening of peak flows of the McKenzie River is demonstrated further in Figure 2-2. A 100-year flow under current reservoir management would have been only a 3-year flow prior to the dams.

The biological consequences of suppressed peak flows include the diminished ability of the river to meander and carve out new side channels, ponds, and alcoves (Miller et al. 1995, Van Steeter and Pitlick 1998, Friedman et al. 1998). Also, the river is less able to keep these off-channel features cleared of fine sediments and keep substrate throughout the river free of fine material. As discussed below, off-channel areas are critical to rearing of some native fish in the McKenzie River and substrate quality is an important component of salmonid reproduction.

There has been some discussion about restoring the peak flow regime of the McKenzie River to some extent by managing peak flows at the reservoirs. However, the magnitude of peak flows required to induce channel meandering and create new off-channel features is probably greater than is socially acceptable. The peak flow of February, 1996, caused considerable damage to some riverfront homes and nearly topped dikes surrounding gravel extraction operations. Yet, few major channel changes resulted from this magnitude of peak flow. Damage to development in the pre-dam flood plain would probably be extensive if flood flows were allowed to exceed the 1996 flow.



Highest flow of record:

No reservoirs (1925-1963); 64,400 cfs in 1946
Cougar reservoir only (1964-1967); 57,400 cfs in 1965
Both reservoirs (1968-1998); 30,459 cfs in 1996

Figure 2-2. Peak flow associated with various return intervals for the McKenzie River with and without dams based on gauge records at Vida from 1924 to 1998 water years.

Monthly flows have also been altered by upstream reservoirs (Figure 2-3). Average flows for months between July and October are now 13 to 49% higher (depending on month) than before dam construction. Conversely, average flows between March and June are now 8 to 27% lower (depending on month) than before dam construction. These changes coincide with reservoir filling in the spring and reservoir releases in summer and fall.

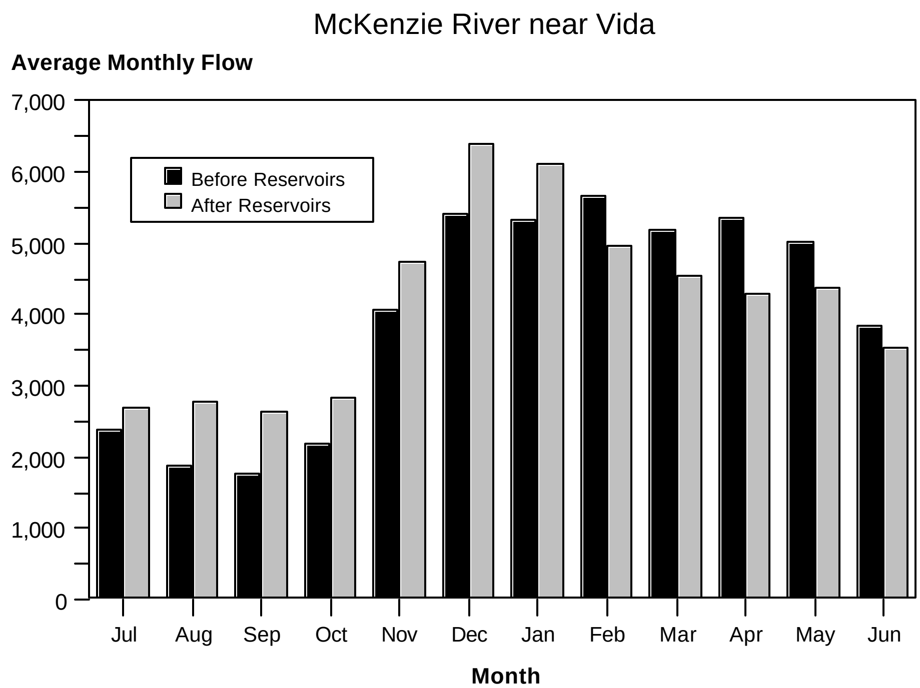


Figure 2-3. Average monthly flow before and after reservoirs for the McKenzie River near Vida.

The biological consequences of lower monthly flows from late winter through early summer have not been evaluated for the McKenzie River but could include the stranding of fish in off-channel features (Bradford 1997). Higher than normal flows in summer and early fall probably benefit fish by keeping water temperature low and providing fish more living space and water depth. Fish could probably benefit from even further flow supplementation in the summer. Yet, the reservoirs (especially Cougar Reservoir) have heavy recreational use during the summer and there would be opposition from fishermen and boaters to extensive summer drawdowns.

Flow diversions for off-river power regeneration occur downstream of Leaburg Lake and near the Walterville School. The Leaburg power canal diversion reduces flow in the main channel for 5.5 miles and the Walterville power canal diversion reduces flow in the main channel for 7.5 miles.

Debate over the minimum amount of water needed to support fish in these partially dewatered segments of the McKenzie River have gone on for decades. A recommended September minimum flow of 425 cfs was made for the Walterville project by the Oregon Fish Commission in 1952 (Mattson and Jensen 1952). Several years later, a recommended minimum flow of 500 cfs was made for the river segment affected by the Leaburg project (Pulford and Jensen 1956). Since 1993, Eugene Water and Electric Board (EWEB) has maintained flows in both reaches at or above 1000 cfs.

From 1982 through mid-1996, under joint agreement between Oregon Department of Fish and Wildlife and EWEB and based on the original analysis of a 1982 ODFW/EWEB study, EWEB operated Walterville canal to assure river bypass flows of at least 1300 cfs during ODFW-identified key migration periods. In 1996, a new agreement between ODFW and EWEB significantly reduces flows into Walterville Canal from October through April, thereby reducing fish entrainment into the canal. EWEB will continue these increased fish protection measures in the interim until a fish screen is completed in 2002.

Drift boats can still maneuver the river at a flow of 1000 cfs. Studies to determine whether or not habitat changes created by these diversions are harmful to chinook salmon and other salmonids have been inconclusive (Hardin-Davis Inc. 1990, Ligon 1991, EA Engineering 1990, EA Engineering 1994).

Recent increases in power costs throughout the Pacific Northwest will probably keep the Leaburg and Walterville hydroelectric projects profitable in the future. Discussion of options for decommissioning the projects for the purpose of improving fish habitat will probably be limited until additional power generation occurs and costs decline. It is unknown how much decommissioning would benefit chinook salmon and other native fishes.

Water temperature

Water temperature can have important influences on the timing of fish fry emergence from eggs, fish growth rates, nutrient cycling in the river, and biological activity of other plants and insects. The water temperature of the McKenzie River and its tributaries varies greatly throughout the basin. Headwater streams begin at only a few degrees above groundwater temperature and warm in a downstream direction as they come into equilibrium with surrounding conditions. Solar radiation and heat exchange with the air act to increase water temperature while additional groundwater, evaporation, and heat loss to the channel bottom act to cool the stream.

The McKenzie River is exceptionally cool for a river of its length and basin size. It receives ample groundwater from the newer porous rocks comprising the upper end of the basin and also from the fractured older volcanic rocks in the lower end. The river may be warmed some by occasional hot springs in the channel (Torgersen et al. 1999).

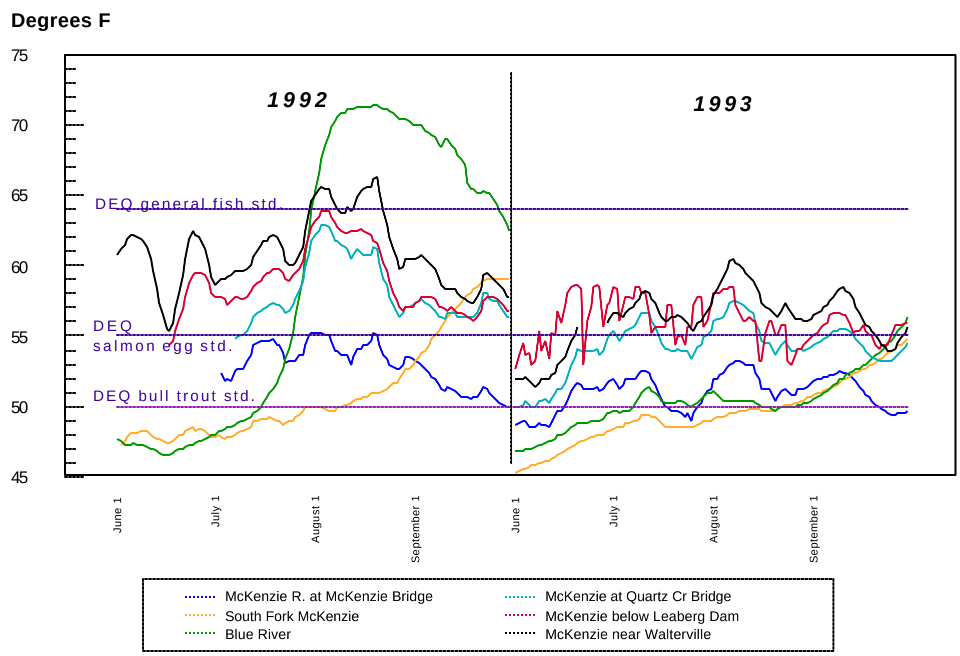
In spite of its unique coolness, the McKenzie River and selected tributaries have been placed on the 303(d) list by the Oregon Department of Environmental Quality (DEQ), as indicated in Table 2-1. This status means that some data exists showing that the stream exceeds DEQ's temperature standard (this varies according to whether or not there is bull trout rearing occurs) but that further analysis is needed to determine whether the stream temperature is naturally higher than the DEQ standard or if human activities have caused it to be warmer than normal. The prescription for cooling a stream that has been warmed by human activities is determined during a Total Daily

Maximum Load (TMDL) process. The TMDL process for water temperature in the McKenzie River basin is scheduled for 2002.

Table 2-1. McKenzie basin reaches on the 303(d) list.

Stream	Reach	Parameter
McKenzie R	Mouth to Ritchie Cr	Temperature - summer
McKenzie R	Ritchie Cr to S Fk McKenzie R	Temperature; bull trout - summer
McKenzie R	S Fk McKenzie R to Clear Lake	Temperature; bull trout - summer
Horse Cr	Mouth to Eugene Cr	Temperature; bull trout - summer
Blue R	Mouth to Blue R reservoir	Temperature - summer
South Fork McKenzie	Mouth to Cougar Reservoir	Temperature - summer
Deer Cr near Belknap	Mouth to headwaters	Temperature - summer
Mill Cr	Mouth to headwaters	Temperature - summer
Mohawk R	Mouth to headwaters	Temperature - summer

7-Day Maximum Water Temperature
June 1 to September 30, 1992 and 1993



Data from U.S.G.S.

Figure 2-4. 7-day maximum water temperature for four McKenzie River sites, South Fork McKenzie River and Blue River in 1992 and 1993.

The water temperatures of the McKenzie River, South Fork, and Blue were monitored (U.S.G.S. 1995) during the summers of 1992 and 1993 (Figure 2-4). The summer of 1992 was unusually warm with relatively low flows (Figure 2-5) while the summer of 1993 was relatively cool and the river had ample flow. Water temperature in the McKenzie River peaked in early August for both years with 1992 values about 3 to 6 degrees F warmer than in 1993. All McKenzie River sites were warmer than the DEQ bull trout temperature standard by mid-summer, even in 1993. In 1992, the South Fork of the McKenzie River continued to warm into August and September as the pool of warm water behind the reservoir was released. The Blue River reservoir was nearly empty in 1992 and contributed very warm water but not much flow. In 1993 flows were higher and both reservoirs contributed cool water to the McKenzie River throughout the summer.

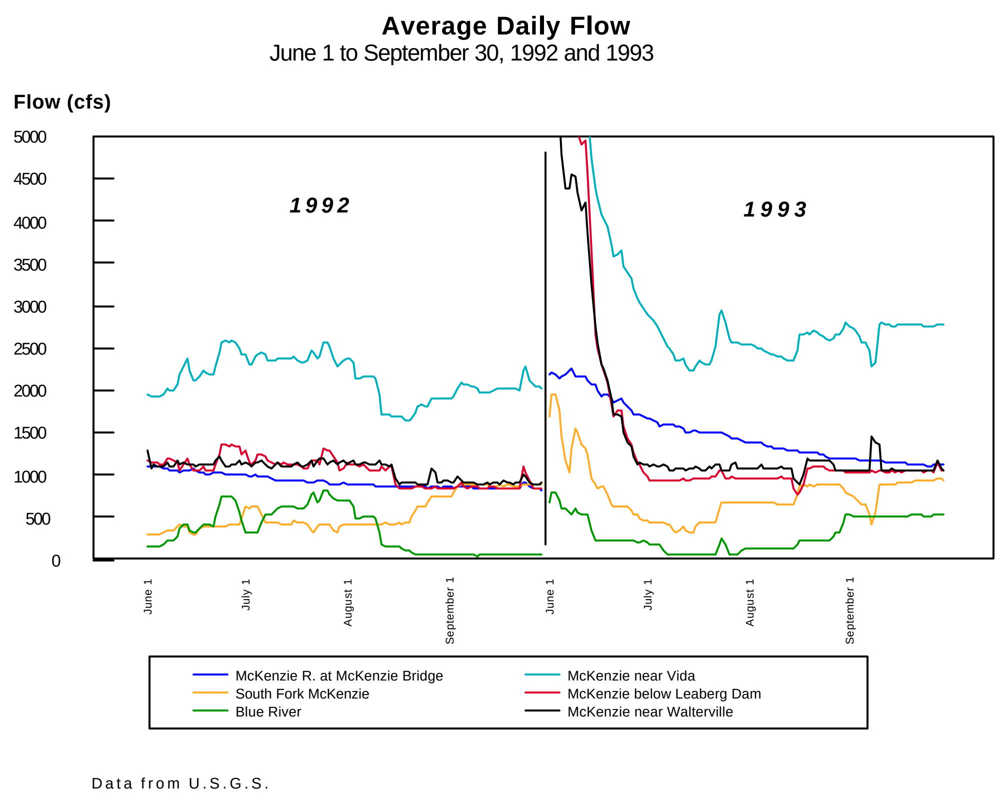


Figure 2-5. River flow for the summers of 1992 and 1993 at sites for which water temperature data was gathered.

These data indicate that the temperature of the McKenzie River is highly variable, both spatially and temporally. Unusually warm water in the South Fork and Blue River in the fall stems from the warm surface layers of the reservoirs being released. Cougar reservoir on the South Fork of the McKenzie River is currently being retrofitted to allow operators the option of changing the temperature of released water.

Tributaries of the McKenzie River basin can be classified into two temperature regimes; those that have drainage basins within the new geology and those in the old geology. Those tributaries in the new geology tend to be cooler than those in the old geology, mainly because of the high flux of cool groundwater they receive.

Tributaries that have been monitored for temperature in the lower McKenzie River (older geology) display wide variability in temperature, with the warmest water usually coming from the largest tributaries. Monitoring of forest streams in 1994 and 1995 by Weyerhaeuser Company indicates a somewhat linear relationship between stream temperature and distance of the temperature gauge from the drainage divide (Figure 2-6).

Streams that are warmer than neighboring streams can be identified by plotting temperature versus distance from drainage divide and looking for sites that plot above a regression line among the cooler or baseline sites. Sites that plot higher than the regression line are likely to be influenced by human activities. For example, water temperature at a site on lower Potter Creek was about 6 degrees F warmer than would be expected when compared to nearby tributaries for the north side of the river (Figure 2-6). Potter Creek exits forest land at a cool temperature but then warms rapidly as it flows through a rural residential neighborhood. Using this method, other warm north side tributaries are South Fork Gate Creek and Finn Creek. Warm south side tributaries are East Fork Deer Creek, Deer Creek (the Deer Creek downstream of Quartz Creek), and Taylor Creek.

Warm streams are often a result of decreased shading due to forest harvest activities that took place at a time when only minimal buffers were retained along streams. Today, considerably more vegetation is retained along streams during forest harvest operations and water temperature increases are usually negligible. Nevertheless, old forest harvest activities may still be influencing some streams, especially along larger streams for which vegetation needs to grow tall before the stream is shaded. Consequently, the water temperature of tributaries is probably going to decline over time. However, there are no similar enforced regulations that require landowners to retain vegetation along streams that do not flow across forest land (e.g., rural residential areas).

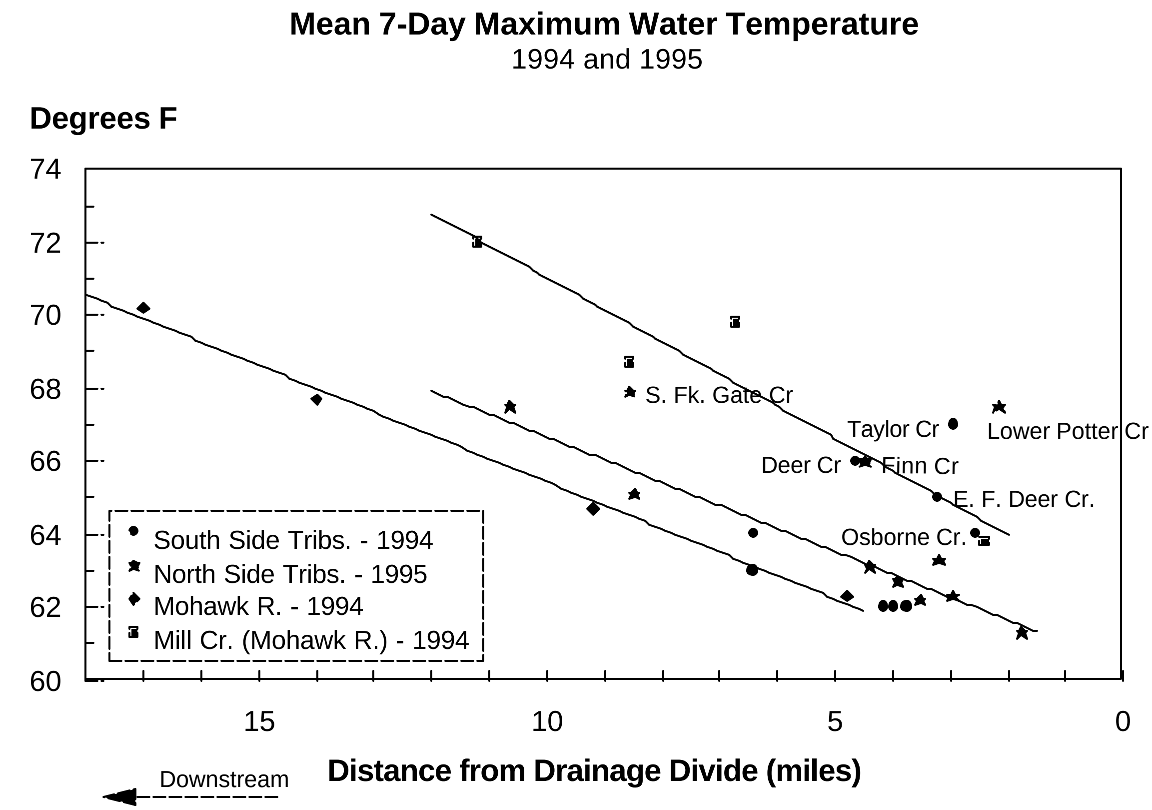


Figure 2-6. Maximum water temperature and distance from drainage divide for selected tributaries of the lower McKenzie River. Data provided by Weyerhaeuser Company.

The water temperature in the two McKenzie River reaches from which water is withdrawn for power generation becomes warmer than usual in the summer due to the reduced flow. The magnitude of this warming was determined using a locally calibrated temperature model (EA Engineering 1994). During a normal summer, the peak water temperature at the downstream end of the affected reach for the Walterville project was estimated to warm 1.0 deg F if the flow was reduced from 1500 cfs to 1000 cfs and warm 1.7 deg F if the flow was reduced from 2000 cfs to 1000 cfs. These values were estimated to be 1.3 deg F and 2.3 deg F, respectively, for an abnormally warm summer. Similar, but somewhat lower values were found for the Leaburg project (Table 2-2). While water retained in the river experienced higher than usual warming, the water that was diverted into the power canal experienced slightly lower warming than usual. When combined with main channel flow, there was no net effect on water temperature downstream of their junction.

Table 2-2. Estimated changes in maximum water temperature for various flows in the channel of the McKenzie River for the two power generation projects.

Project	River channel change in flow (cfs)	Increase in max. temperature (deg F) *Normal summer*	*Warm summer*
Walterville	Reduced from 1500 to 1000	1.0	1.3
	Reduced from 2000 to 1000	1.7	2.3
Leaburg	Reduced from 1500 to 1000	0.7	1.1
	Reduced from 2000 to 1000	1.1	1.7

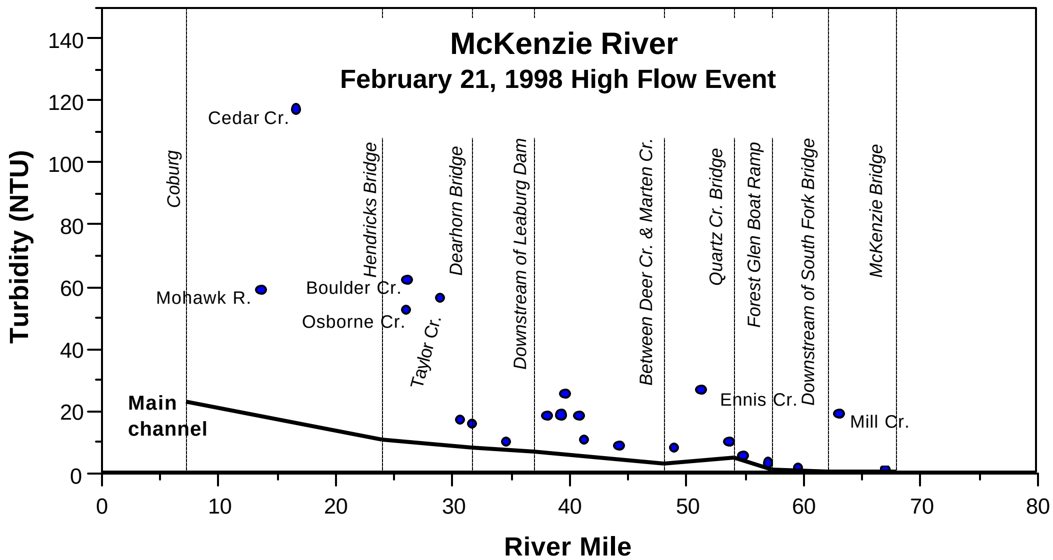
Turbidity and suspended sediment

Water turbidity is a measure of the scattering of light within water. Turbidity can be caused by algae suspended in the water, color (e.g. leaf-stained water in the fall), clay particles, or larger sediment particles suspended in the water. In a river such as the McKenzie, turbidity during high water is dominated by suspended sediment. So the two measures, turbidity and suspended sediment concentration, are indicating mostly the same thing. Turbidity is a relatively easy measure to make in comparison to suspended sediment concentration, so the former is often used for indirect monitoring of suspended sediment (Gippel 1995).

Increased turbidity during heavy rainfall is a result of the stream scouring out landslide deposits in the channel, re-suspending fine particles in the channel, carving at the streambank, and some surface erosion. Human activities can add to natural turbidity through road runoff and landslides, disturbance to streambanks, surface erosion at construction sites, runoff from bare farm land, and stormwater runoff from paved surfaces within urban areas. The consequences of excessive turbidity in a river can include, the extra risk of bacterial contamination and increased treatment cost associated with making safe drinking water, an increase in the number of days where angling conditions are poor, a reduction in fish egg survival, and a reduction in the abundance and diversity of aquatic insects available for fish to eat.

Joint storm monitoring conducted by the McKenzie Watershed Council and Partner Organizations in 1998 (Runyon 2000) indicates that turbidity in the main channel is usually less than in the tributaries (Figure 2-7). During two largest winter storms that were monitored, the turbidity never exceeded 30 NTU in the main channel. The February 21 storm caused a considerable increase in turbidity within tributary streams downstream of Deerhorn Bridge but not much in upstream tributaries. In contrast, turbidity was greatest in tributaries downstream of the Quartz Creek Bridge and upstream of Leaburg Dam during the December 2 storm (Figure 2-7). Much of this difference among tributaries is probably due to variability in precipitation intensity and amount during the storms.

The highest turbidity levels on February 21 occurred in Cedar Creek. The turbid water was traced to a tributary of Cedar Creek that was receiving sediment-laden water from a building construction site at the edge of Springfield.



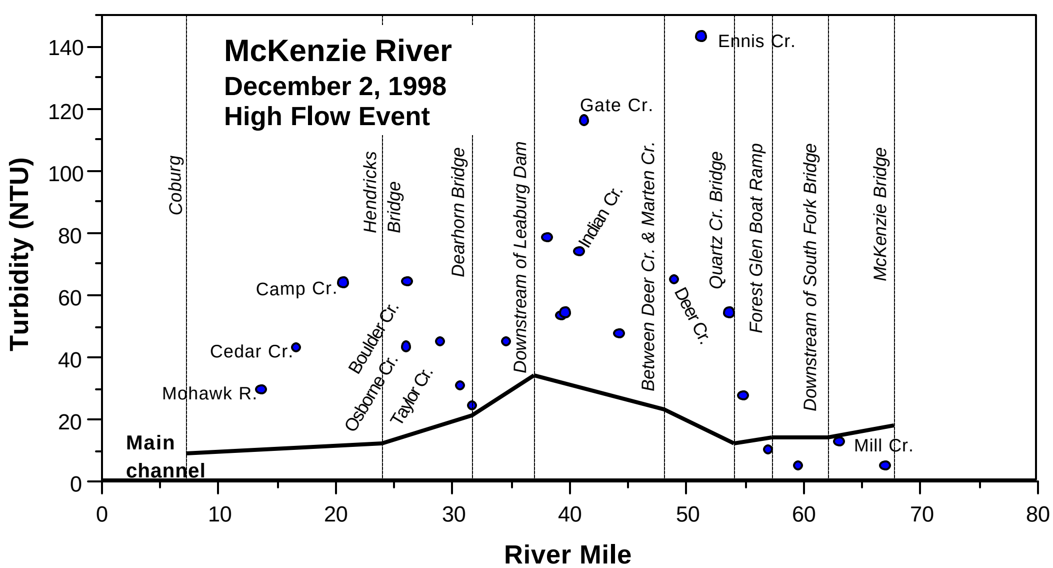


Figure 2-7. Turbidity levels for tributaries and the main channel in the lower McKenzie River basin for two high flow events in 1998 (Runyon 2000).

Annual loads of suspended sediment (tons per year per square mile of drainage area) in the McKenzie River decreased significantly following construction of the two reservoirs. A comparison of data collected from 1948 to 1951 (before reservoirs) by the Corps of Engineers and from 1991 to 1993 (after reservoirs) by the U.S. Geological Survey indicates that the relationship between daily sediment load and daily flow is not different for the two time periods. This suggests that the net supply of sediment available for movement has not changed during the last 50 years (Figure 2-8). However, the dampening of peak flows at reservoirs has reduced the energy available to transport sediment.

The suspended sediment vs. flow relationship was combined with actual daily flow data for the two time periods, and an estimate of annual sediment load was calculated. The results indicate that the current annual suspended load averages only 59% of that prior to reservoir construction (Figure 2-9). Consequently, deposition of fine sediments along the river is probably less now than before the reservoirs.

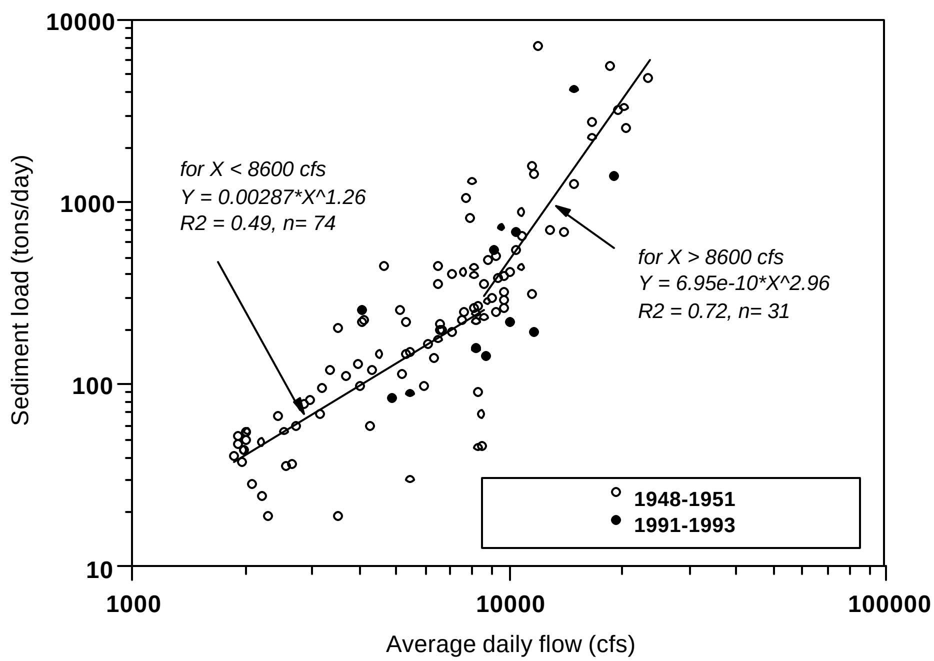


Figure 2-8. Relationship between average daily flow and suspended sediment load for the McKenzie River at Coburg prior to dam construction (1948-1951) and after dam construction (1991-1993). Suspended sediment data gathered by the U.S. Corps of Engineers from 1948-1951, and by U.S.G.S. from 1991-1993.

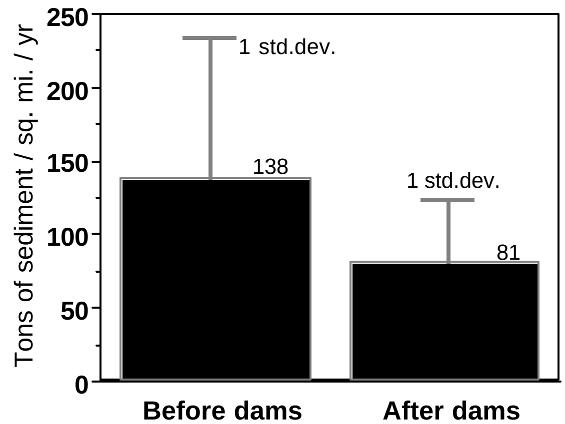


Figure 2-9. Modeled average unit annual load of suspended sediment for the McKenzie River at Coburg before dam construction (1940-1963) and after dam construction (1969-1998).

The relative contribution of sediment from forests of various ages and from logging roads was determined for an area in the upper South Fork Gate Creek following the February, 1996, storm (Robison et al. 1999). Landslides on the hillslopes in the core area were 8 times more numerous than road-related landslides, when expressed on a per unit area basis (Table 2-3). But road-related landslides were larger and so the per unit landslide erosion rate was about the same between roads and hillslopes. Only landslides that entered a stream channel were included in the inventory.

Table 2-3. Landslide density and erosion rate in upper South Fork Gate Creek following the February 1996 storm (Robison et al. 1999).

	Related to Roads	Not Related to Roads
Landslide density (#/sq.mi.)	0.9	7.4
Landslide erosion rate (cu.yd./ac.)	3.3	3.1
Landslide erosion rates by forest age class (cu.yd./ac.)		
0-9 years old		6.6
> 100 years old		2.0

Stand age influenced the density of landslides on hillslopes. Landslide erosion rates were over 3 times greater on slopes with young trees (0-9 years) than those with trees greater than 100 years old. Because the landslides were located in the field rather than by using aerial photographs the authors avoided the inevitable undercount that occurs when trying to locate landslides beneath a forest cover. The areas with forest stands between 100 years or more were slightly steeper than areas with young stands between 0 and 9 years.

Higher landslide erosion rates on slopes that have been recently harvested are likely associated with a loss of root strength in the upper mantle of the soil once the roots decay. This accelerated rate of landslide occurrence following root decay is likely to be followed by a dampened rate of landslide occurrence as the new generation of trees establishes its roots. This phenomenon has probably always occurred in the McKenzie River basin; stands were killed by wildfire and then replaced by a new forest.

Other water quality parameters

Water quality in the McKenzie River is important for downstream communities that rely on the McKenzie River for drinking water, for fish and insects that are sensitive to nutrient levels, and to plants growing in and along the river. Water monitoring by the Corps of Engineers and the Oregon Department of Environmental Quality in 1999 provides an opportunity to examine patterns of water quality in the main channel from McKenzie Bridge to the Coburg Road Bridge near the Willamette River confluence and in three major tributaries (USCE 2000), (Cude 2000). The parameters discussed below relate to nutrient cycling and biotic activity in the reservoirs and rivers and are for three periods: April, July, and September.

Nitrogen available for biotic uptake. Nitrogen that is immediately available for use by water-born organisms includes that contained within nitrate, nitrite, and ammonium. Bioavailable nitrogen and soluble reactive phosphorus are two forms of nutrients that drive biotic activity in rivers and lakes.

Bioavailable nitrogen concentrations were very low (< 0.06 mg/L) in the McKenzie basin for each of the three sampling periods, except within the Mohawk River during April (0.14 mg/L). Values are lowest in July and September, the time when biotic uptake processes are most active (Figure 2-10). No consistent downstream pattern is evident in the McKenzie River. Water that is released from Cougar and Blue River reservoirs has slightly higher nitrogen levels than the McKenzie River. Water discharged from these reservoirs originates from the bottom of the water column, which receives no sunlight to trigger uptake of available nitrogen.

Total soluble nitrogen. Total soluble nitrogen includes both bioavailable nitrogen and nitrogen that is not immediately available for uptake. This second form includes nitrogen leakage from aquatic plants in the river or lake.

Total soluble nitrogen is relatively constant throughout the McKenzie River and is highest in July (Figure 2-11). Again, water released from the main reservoirs has a higher concentration of total soluble nitrogen than does the McKenzie River. Overall, values in both the McKenzie River and the reservoirs are relatively moderate compared to other western rivers.

Soluble reactive phosphorus. The concentration of soluble reactive phosphorus is usually the nutrient in most demand for biotic activity in western rivers. It is usually in short supply except where there are human inputs (usually from sewage treatment plants).

Soluble reactive phosphorus concentrations in the McKenzie River are very low (<0.05 mg/L) and generally decrease in a downstream direction (Figure 2-12). The young geology of the upper McKenzie basin yields higher water phosphorus concentrations than does the older volcanic rocks of the lower McKenzie basin. In addition, instream biotic activity is greater in the lower McKenzie basin due to greater exposure of water to the sun and the lower gradient.

The reservoirs are a sink for soluble reactive phosphorus. Algae growing in the reservoirs tightly cycles the available phosphorus. As a result, concentrations in the outflow water from the reservoirs are only slightly above detection limits in July and September.

There is no indication that phosphorus from the leach fields of riverfront homes is influencing phosphorus levels in the McKenzie River. Soluble phosphorus concentrations decreased slightly from Finn Rock to Hayden Bridge, the segment with the greatest number of riverfront homes. A more detailed study would need to be done to determine how much phosphorus originates from riverfront homes.

<u>Dissolved organic carbon.</u> Dissolved organic carbon is a result of decay of wood, aquatic plants, and other organisms. It is also an essential component for plant growth within the river channel.

Dissolved organic carbon concentrations were at moderate levels and were relatively constant throughout the McKenzie River (Figure 2-13). Reservoir release water had concentrations of carbon that were only slightly greater than the river. Carbon concentrations were lowest in September, a time when attached algae and other aquatic plants are reaching their maximum biomass of the year.

<u>Chlorophyll a.</u> Chlorophyll *a* concentration in the water column is an indicator of the level of suspended algae production in a river or lake. Concentrations in the McKenzie basin were relatively low compared to other lakes and large rivers in the west. Values did not vary longitudinally for the McKenzie River (Figure 2-14). Release water from Blue River reservoir had greater concentrations of chlorophyll *a* than did the main channel for July and September but this was not true for release water from Cougar reservoir. Blue River reservoir is the first of the two to be drawn down during the summer and the last water to be released includes the surface layer, for which photosynthetic processes are most active.

<u>Dissolved oxygen.</u> Dissolved oxygen concentrations are an indicator of the level of photosynthesis and of decay occurring in a river or lake. Rapids cause some water aeration and are also a part of the equation. Dissolved oxygen measurements taken during daylight hours reflect mostly photosynthetic processes while nighttime measurements reflect mostly decay processes. The following dissolved oxygen

measurements collected by the Corps of Engineers and Department of Environmental Quality were taken during the day.

Dissolved oxygen values were uniformly high throughout the river in April, July, and September (Figure 2-15) with values seldom less than 10 mg/L. Values were lower in July and September than in April but this is because the water was warmer during the summer. Water can hold less oxygen when it is warm. In September, dissolved oxygen values in the Mohawk River dropped below 9 mg/L but this low value was mostly because the river temperature had warmed above 70 deg F.

pH. The pH of a river or lake reflects, in part, the level of photosynthetic activity. Usually, high levels of algae and other aquatic plants will cause the pH to increase.

Levels of pH were relatively constant throughout the river for all sampling sessions (Figure 2-16). This suggests that activity levels of algae and other plants are relatively uniform throughout the main channel.

E. coli. bacteria. E. coli. bacteria can be an indicator of fecal contamination in a river. E. coli. occupy the guts of mammals and, while not harmful to humans, their presence suggests that harmful bacteria may also be present.

Samples were collected for analysis during storm event monitoring conducted by the McKenzie Watershed Council and Partner Organizations in 1998 (Runyon 2000). For the three storms that were monitored, E. coli. levels were very low in the McKenzie basin except in the Mohawk River and at the most downstream site at the Coburg Bridge site during the February 21 storm (Figure 2-17). The Mohawk River had a level of 380 organisms per 100 ml which approached the DEQ standard for E. coli. (406 organisms per 100 ml). Likely sources of fecal contamination in the Mohawk River are failing septic systems and livestock. Additional sampling by the McKenzie Watershed Council indicated that a tributary of Cedar Creek that drains areas within Springfield had high bacterial counts.

Heavy metals. Heavy metal concentrations were also evaluated during the storm event monitoring mentioned above. High heavy metals in water can be an indicator of pollution due to manufacturing processes or from mines. Heavy metals can also be present in high concentration within the effluent of sewage treatment plants. Some heavy metals such as mercury, iron, and copper can be naturally high in a river because of the underlying rock.

Iron and copper were present in the river at moderately high levels but this is probably a reflection of the geology in the upper end of the watershed. Other heavy metal concentrations were very low in the McKenzie River at the Coburg Road bridge and less than the water quality criteria developed by the Oregon Department of Environmental Quality (Table 2-4).

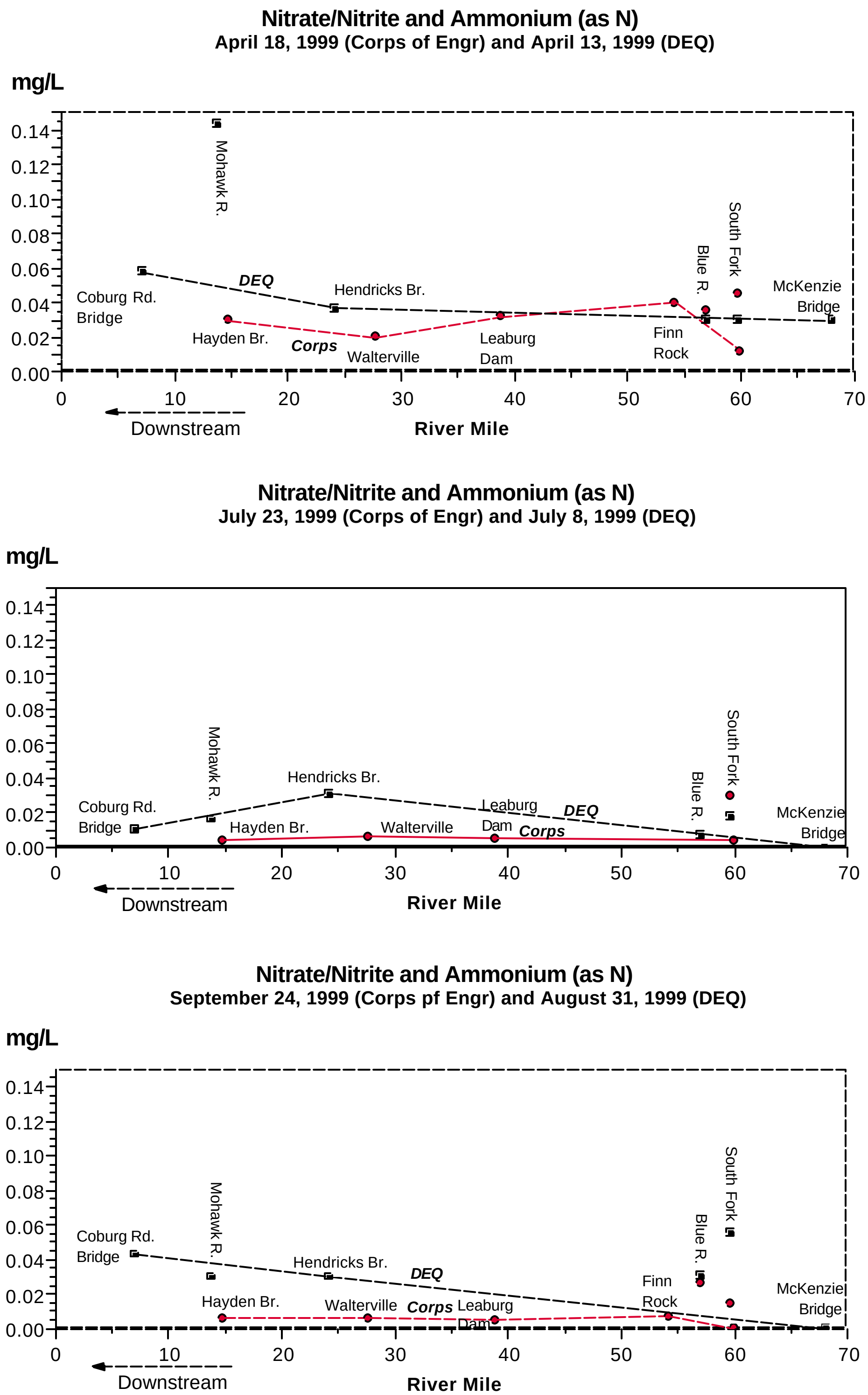


Figure 2-10. Nitrogen available for biotic uptake (nitrate, nitrite, ammonium) for the McKenzie River and large tributaries in summer, 1999.

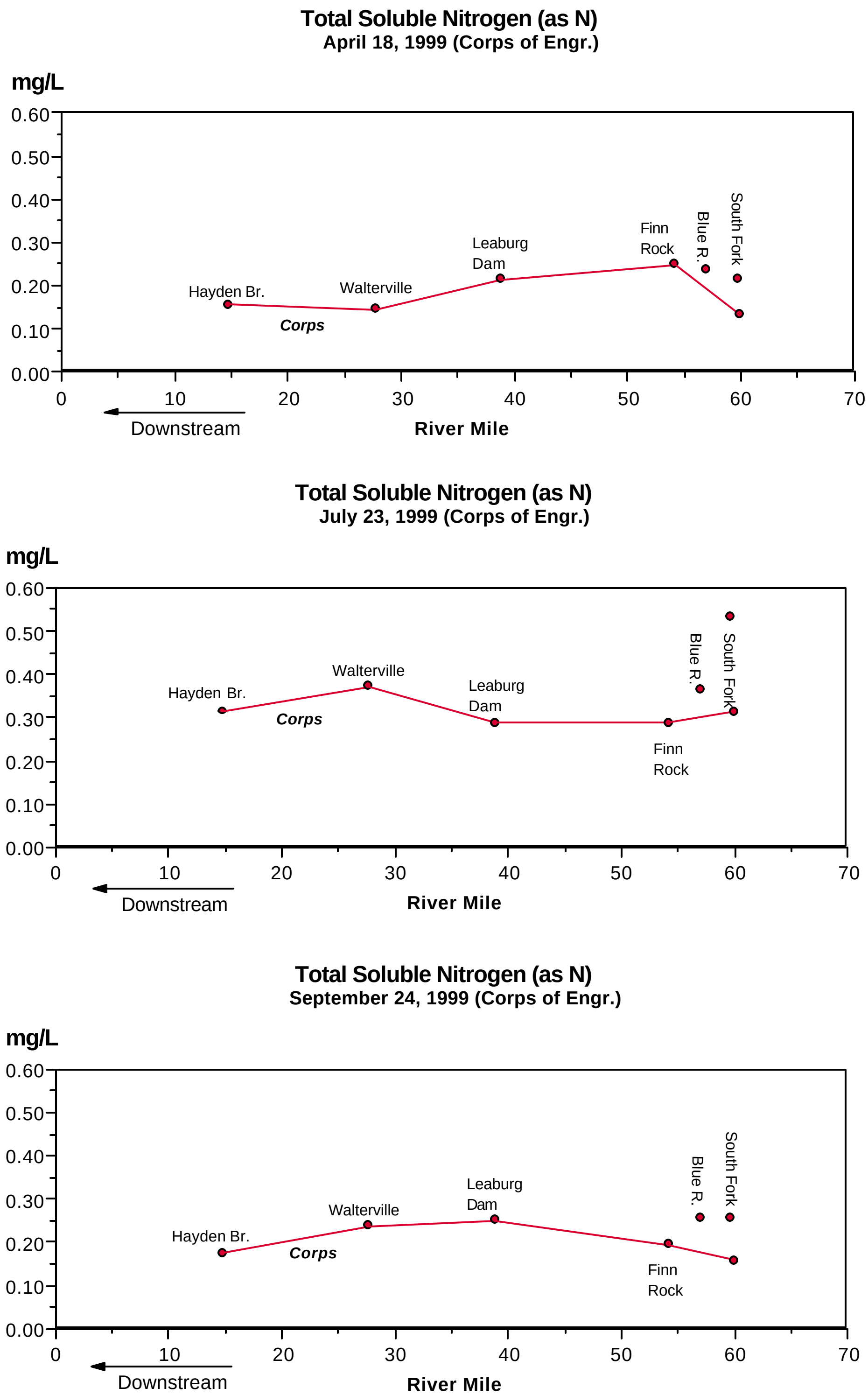


Figure 2-11. Total soluble nitrogen for the McKenzie River and large tributaries in summer, 1999.

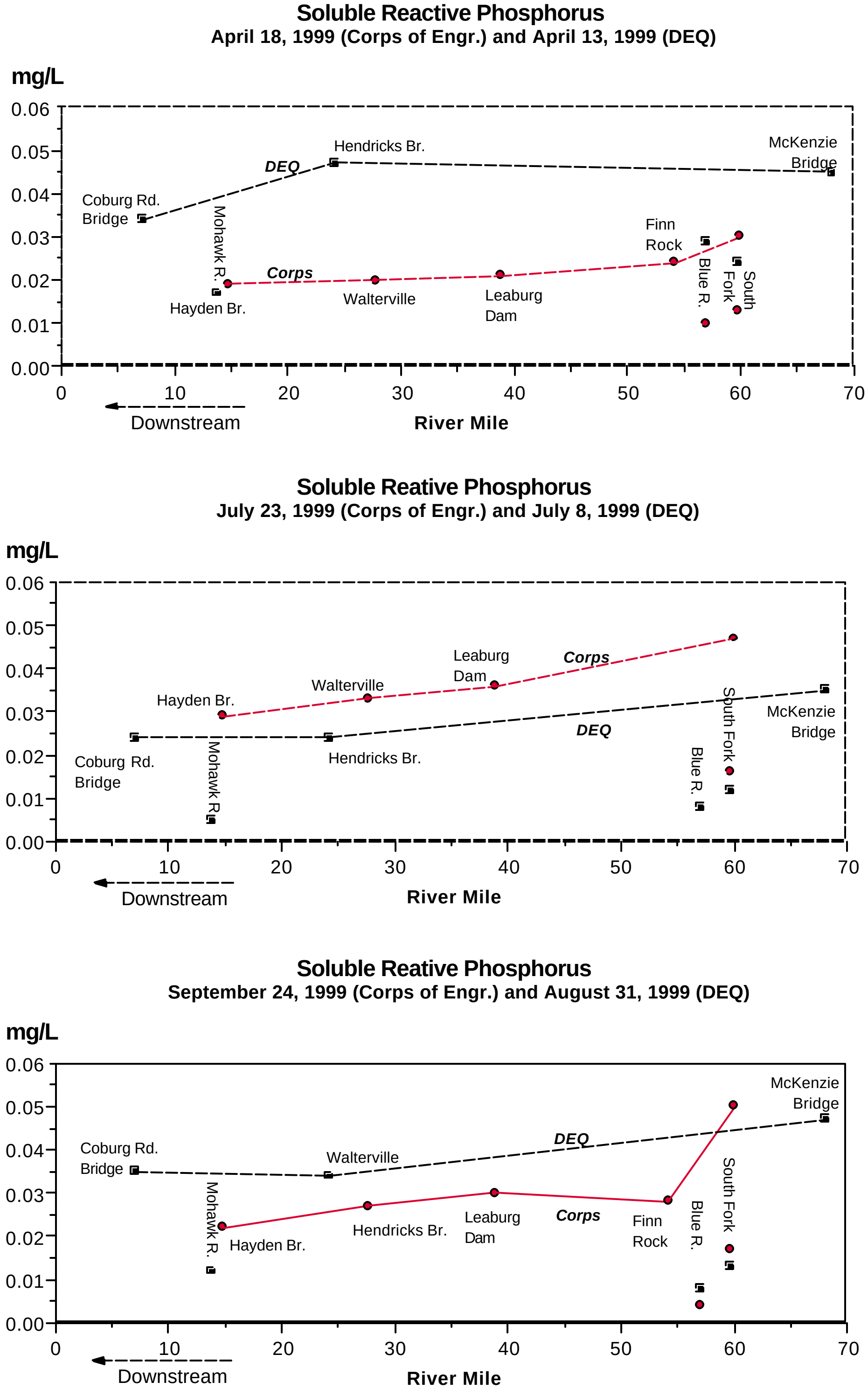
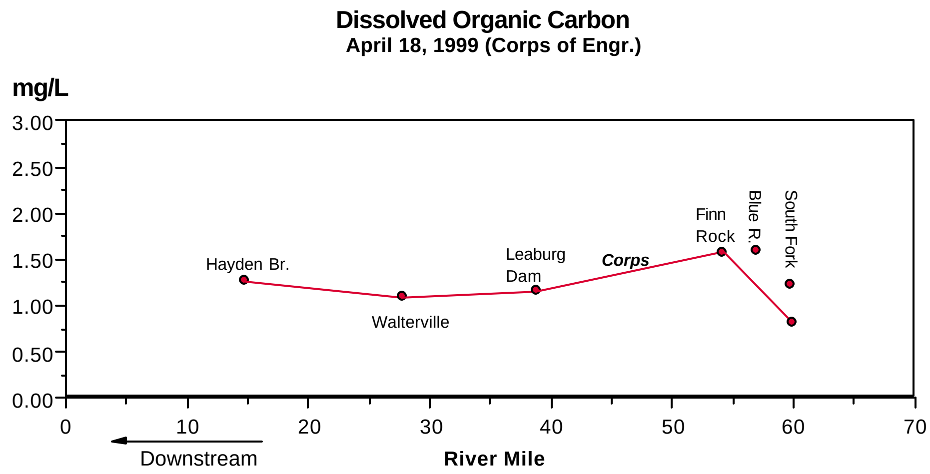
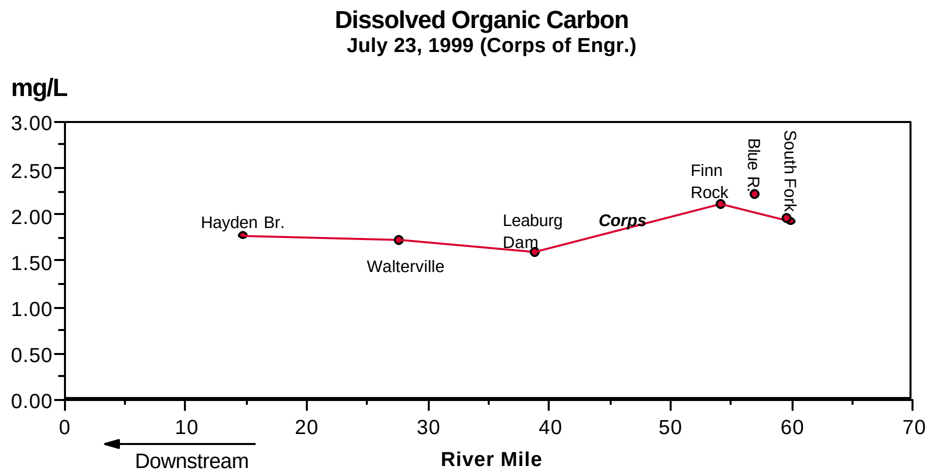


Figure 2-12. Soluble reactive phosphorus for the McKenzie River and large tributaries in summer, 1999.





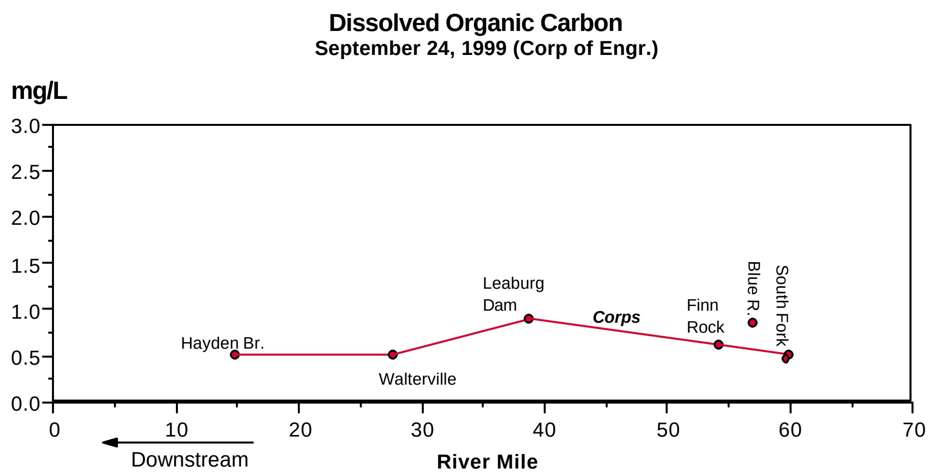


Figure 2-13. Dissolved organic carbon concentrations for the McKenzie River and large tributaries in summer, 1999.

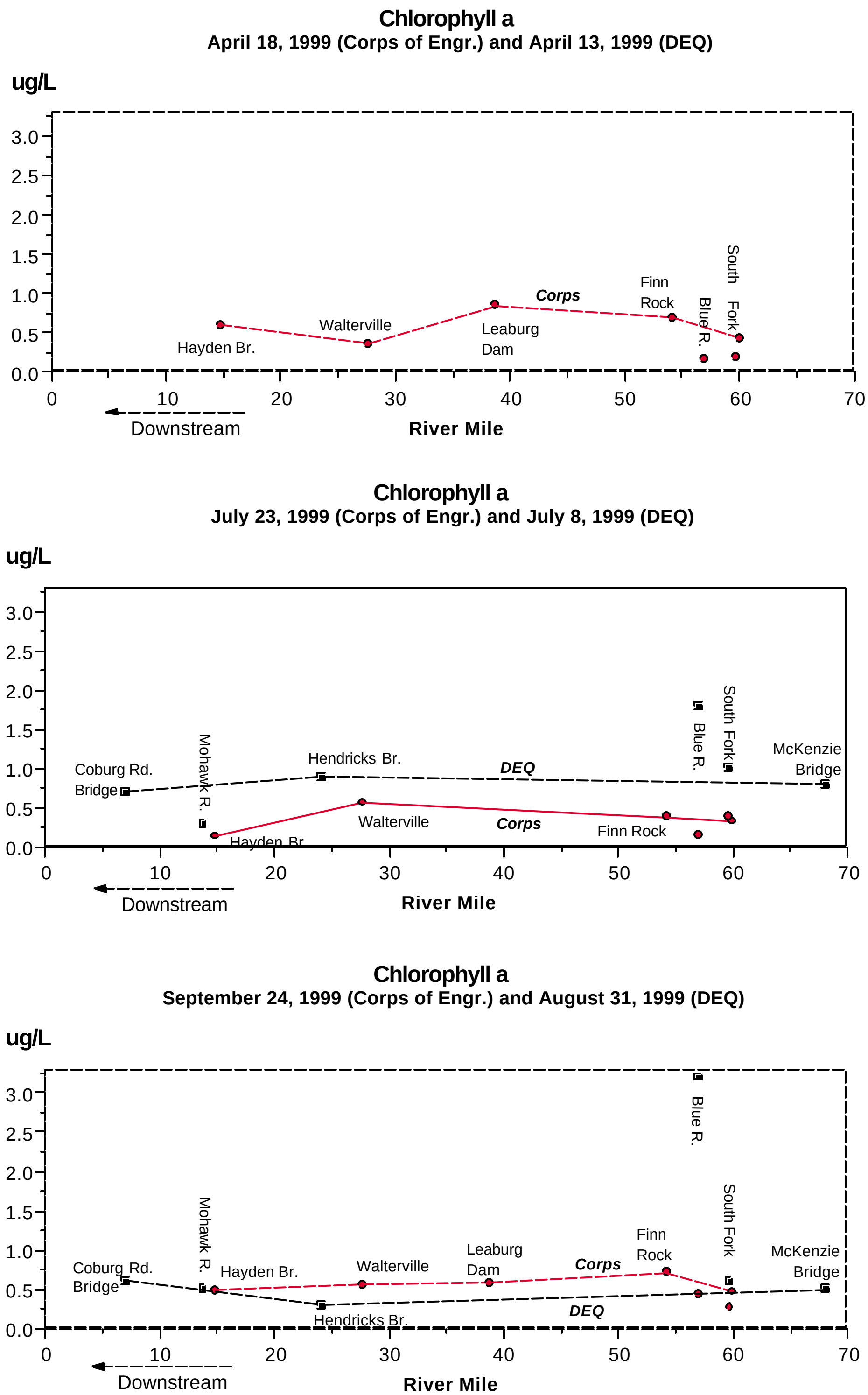


Figure 2-14. Chlorophyll *a* concentrations for the McKenzie River and large tributaries in summer, 1999.

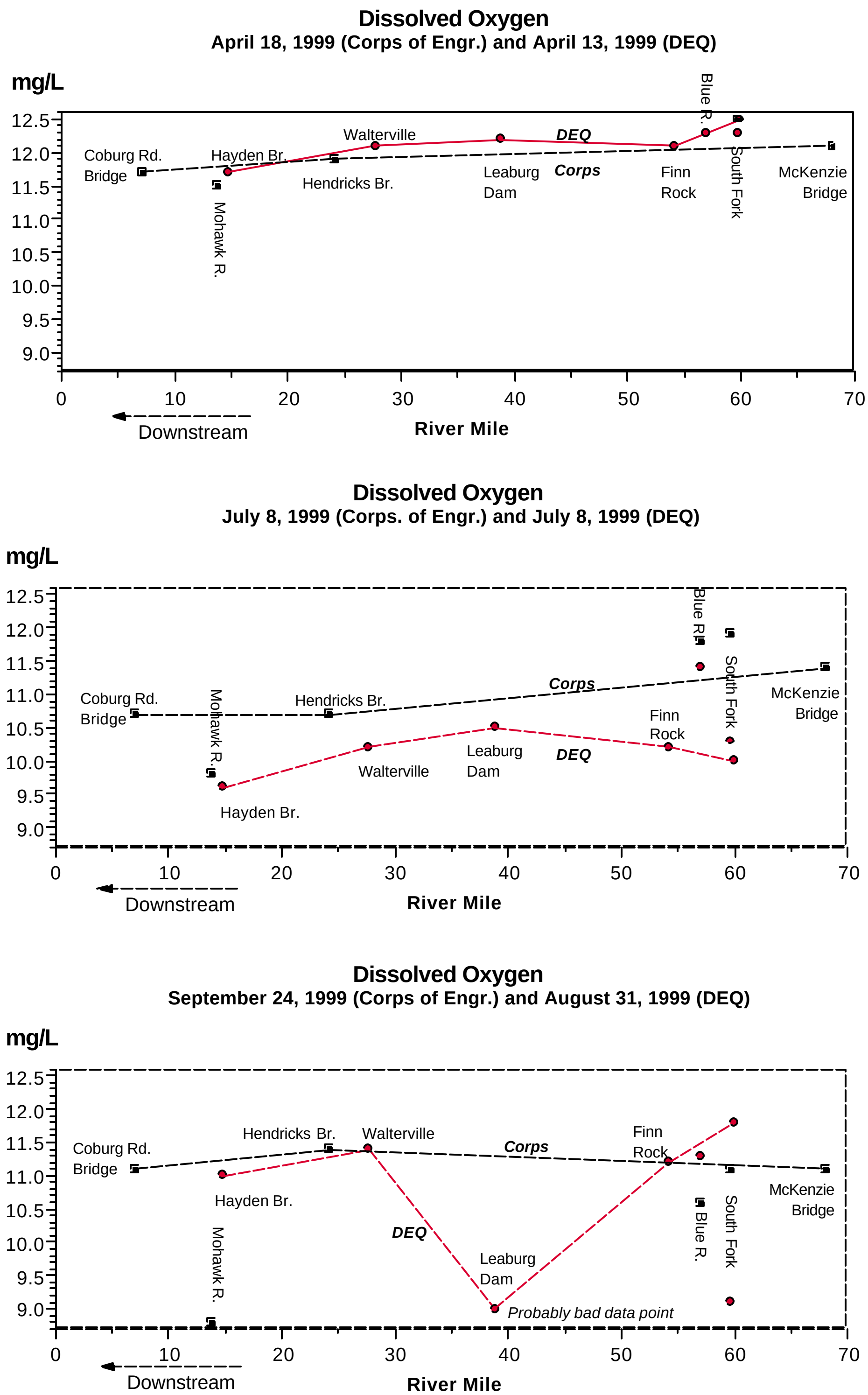


Figure 2-15. Dissolved oxygen levels for the McKenzie River and large tributaries in summer, 1999.

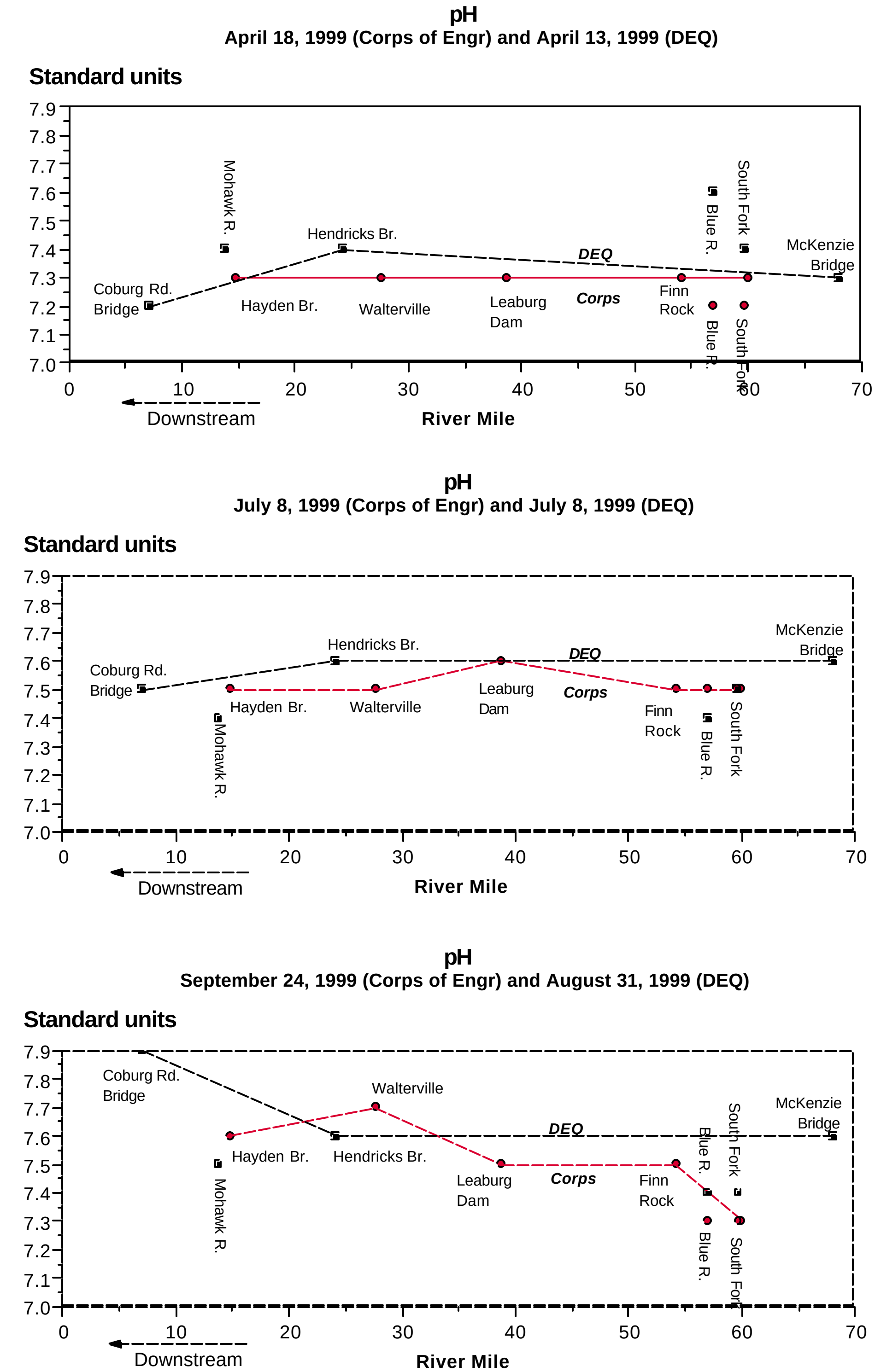


Figure 2-16. pH levels for the McKenzie River and large tributaries in summer, 1999.

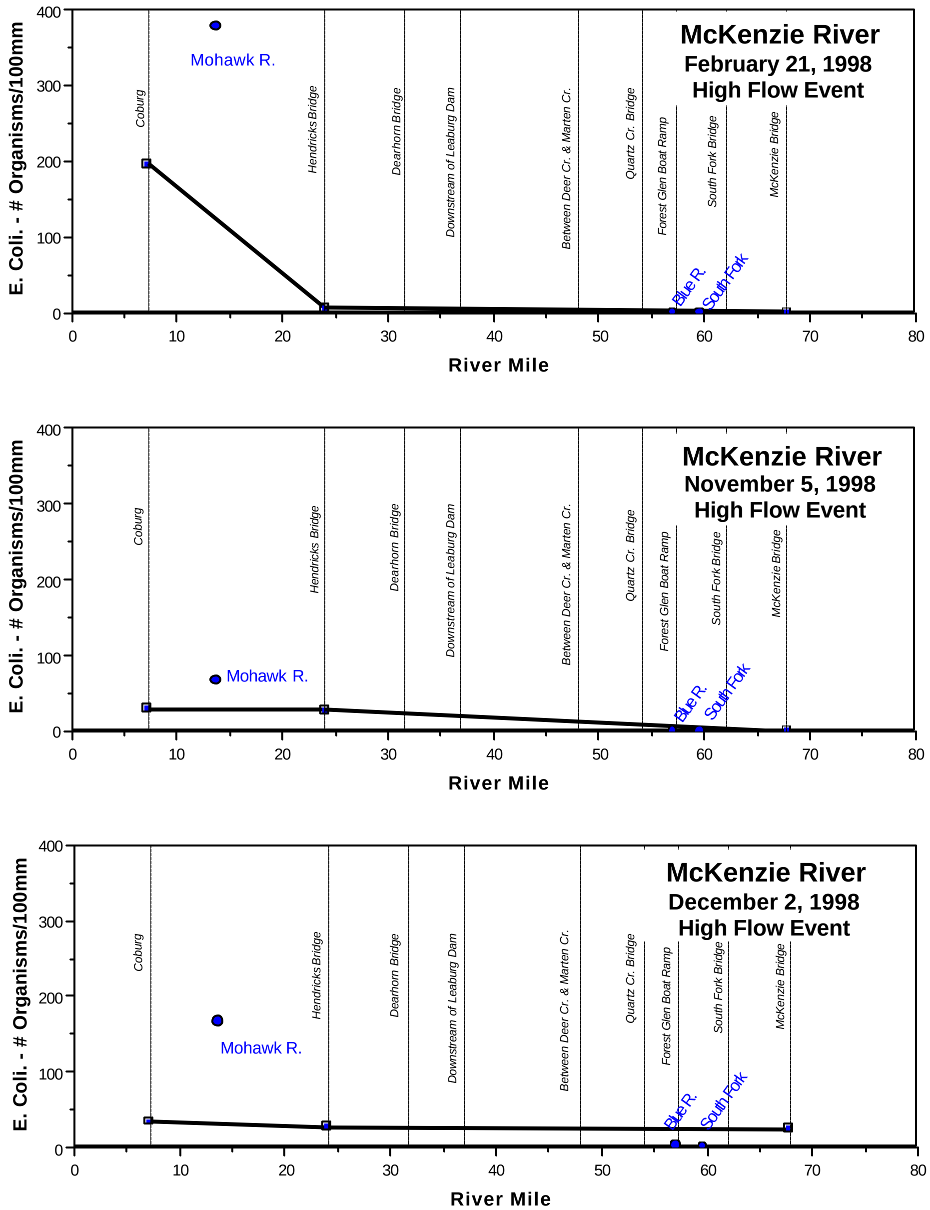


Figure 2-17. E. Coli. bacteria concentrations for the McKenzie River and large tributaries in summer, 1999.

Table 2-4. Highest heavy metal concentrations measured among three storms in 1998 near the mouth of the McKenzie River.

Element	DEQ Criteria (*u*g/L)	Highest concentration measured (*u*g/L)
Arsenic	190	1.5
Barium	NA	22
Cadmium	1.1	<0.02
Chromium	11	1.5
Copper	5.2	3.3
Iron	1000	534
Lead	3.2	0.69
Manganese	NA	89
Mercury	0.012	0.002
Selenium	35	<1.4
Silver	0.12	<0.01
Zinc	110	6.2

Channel complexity

In this report, channel complexity refers to the variability in channel shape caused by sinuosity, islands, and off-channel appendages. These off-channel appendages can include side channels, alcoves (like side channels but with no upstream surface water connection with the main channel during lower flows), and ponds. The ponds may be connected or disconnected from the main channel depending on the flow. Channel complexity is important to fish because it provides the large variety of habitat types needed at different life stages and seasons for reproduction, rearing, and refuge (Taylor 1988, Swales and Levings 1989, Swales et al. 1986, Richards and Cernera 1992, Pearsons et al. 1992).

Using current and historic topographic maps Ligon et al. (1995) determined that the total wetted area of the McKenzie River decreased 28% and island perimeter decreased 41% from 1930 to 1990. This analysis was from Leaburg Dam downstream to the Willamette River confluence with the McKenzie River. They argued that by reducing peak flows, and thereby curtailing the river's ability to meander, create new courses across the flood plain, undercut banks, and locally deposit excess bedload at mid-river locations, a river eventually forms into a single thread with few islands or other off-channel areas.

We conducted a spatial analysis of current off-channel features of the McKenzie River from Quartz Creek to the mouth of the river using 2000 aerial photographs. Polygons of various water features, vegetation by class, and development were mapped and buffers of various widths established along the river. The buffers extended from the edge of the main channel or any side channel or alcove. Buffer widths were 500 feet, 1000 feet, and 2640 feet.

We found that alcoves are present mostly in the lower one-half of the study area (Figure 2-18). Upstream of Hendricks Bridge, the valley becomes restricted by steep hill slopes and the channel rarely meanders. Alcoves are created by the formation and abandonment of side channels. This abandonment occurs when the main channel shifts a distance away from the side channel. Alcoves are most common between Hendricks and Hayden Bridge and in the Willamette River between the current and old McKenzie River confluences. Except for the south side of reach #4, alcoves are scarce from the Hwy I-5 Bridge to the current McKenzie confluence. Here, the river has been channelized to allow gravel extraction.

Alcoves are more abundant today than they were in 1944. Most of the difference occurs between Hendricks Bridge and Hayden Bridge (Figure 2-18, Figure 2-24a). Side channels are less abundant today than they were in 1944 (Figure 2-19, Figure 2-24a) and this is probably related to the concurrent increase in alcoves. A dampening of peak flows since 1966 has likely allowed side channels to gradually fill with sediment at their upper ends and be transformed into alcoves.

Side channels are present throughout the river, with the greatest densities occurring in the Willamette between the new and old confluences (Figure 2-19). The highest value occurs at reach #17 where the channel is split by a large island. Here, the most navigable channel was designated as the main channel and the other a side channel. Other areas of higher side channel area include reaches immediately upstream of Hayden Bridge, immediately downstream of Deerhorn Bridge, and reach #7.

Side channels are less abundant in 2000 than in 1944 primarily due to the loss of nearly all side channels in the lower McKenzie River where gravel extraction occurs (Figure 2-24a).

Natural ponds, like alcoves, are restricted mainly to the lower one-half of the study area. Nearly all these ponds occur in abandoned river channels and so it is not surprising to find them only where the river has recently meandered. The area of natural ponds is greatest along the Willamette River between the new and old confluence (Figure 2-20). Most ponds occur in the old abandoned McKenzie River channel which parallels the main channel. Natural ponds are also common in reaches #17 and #18, located between Hendricks Bridge and Deerhorn Bridge. These reaches include McNutt Island, which is the largest island in the study area. Pond area is also high in reach #12.

Natural pond area was less in 1944 than in 2000 (Figure 2-20). Natural pond area is currently high downstream of the current McKenzie confluence and between Hendricks Bridge and Deerhorn Bridge.

When the area of these three off-channel features are combined, the density is greatest within the section between Hendricks Bridge and Hayden Bridge and the section between the new and old confluences in the Willamette River (Figure 2-21). In addition, the north side of reach #14 is exceptionally high. The reach between Hayden Bridge and Hwy I-5 Bridge has lesser off-channel area, which is probably due to river constriction by the City of Springfield on the south side and steep hills on the north side.

Off-channel area is slightly greater today than in 1944 for reaches between the current confluence and Hendricks Bridge. Upstream of Hendricks Bridge to Leaburg Dam the opposite is true; off-channel area was higher in 1944 (Figure 2-24).

The width of the river currently increases in a downstream direction beginning from Leaburg Dam. However, the width of the river was relatively constant in 1944 (Figure 2-22). For all reaches combined, the per unit main channel area (or channel width) has not changed much over the last 56 years. Aerial photographs from 1944 show the McKenzie River downstream of the Hwy I-5 Bridge occupying a flood plain between one-half to one mile wide. In the upper one-half, the river had a single main channel with many high-water channels branching to the south and north. Further downstream, the river split into two major channels flowing parallel to each other at a distance of one-quarter mile. In addition, numerous small side channels dissected this lower delta (Andrus et al. 2000). Currently the McKenzie River flood plain is about 900 feet wide and consists mostly of a single channel.

Island area, another measure of channel complexity, is currently greatest between Deerhorn Bridge and Hendricks Bridge. The largest islands occur in reach #17 (McNutt Island) and reach #19 (Kaldor / Rodman Island). Small islands are common in reaches between Hendricks Bridge and Hayden Bridge, in reach #7, and in reach #1. A medium-sized island occurs in reach #37 and it consists of cobbles deposited by Quartz Creek which enters the McKenzie River on the opposite bank.

Overall island area today is about what it was in 1944. Losses in island area in the gravel extraction area downstream of Hwy I-5 are offset by the creation of McNutt Island (reach #17) since 1944 (Figure 24b).

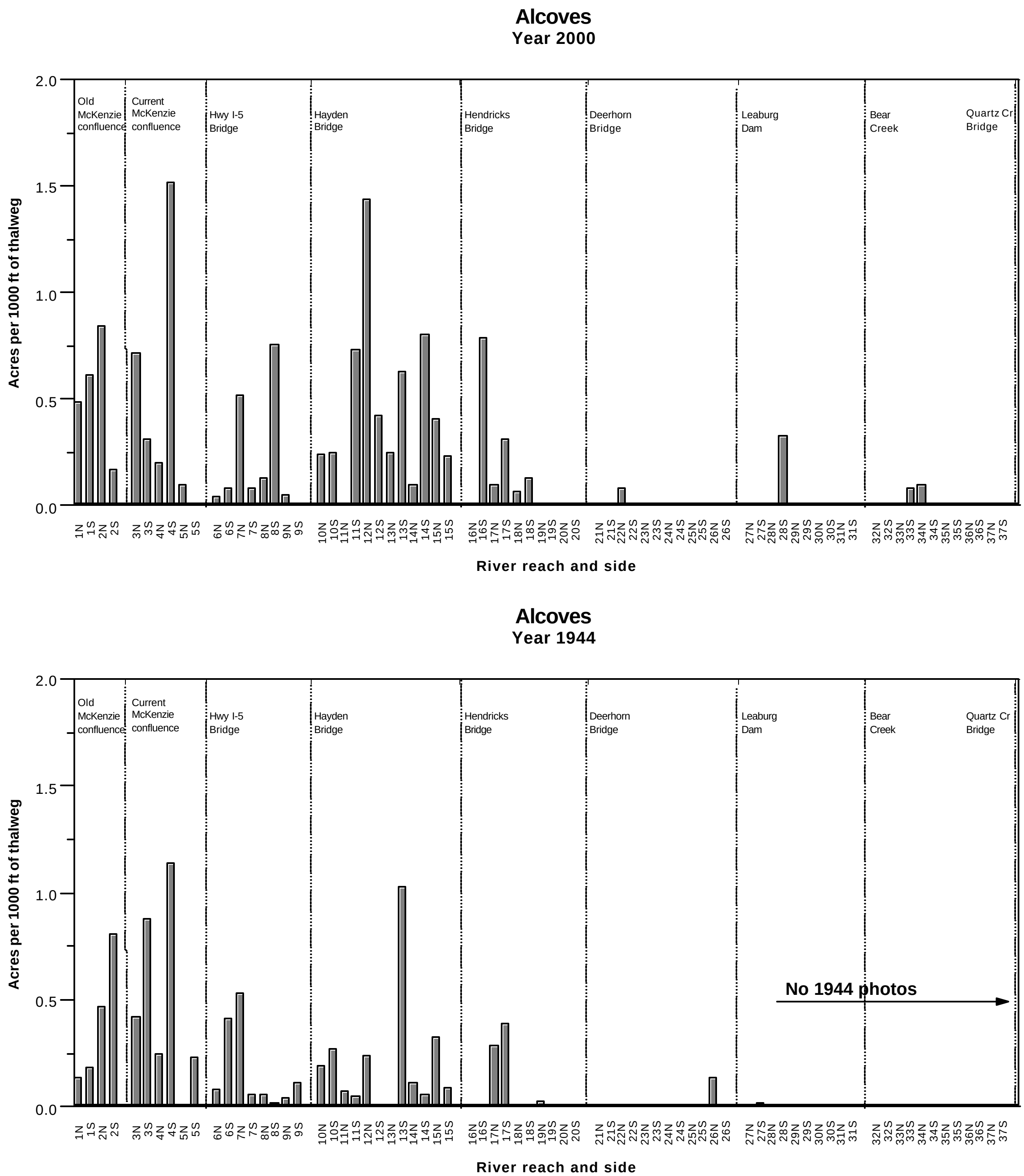
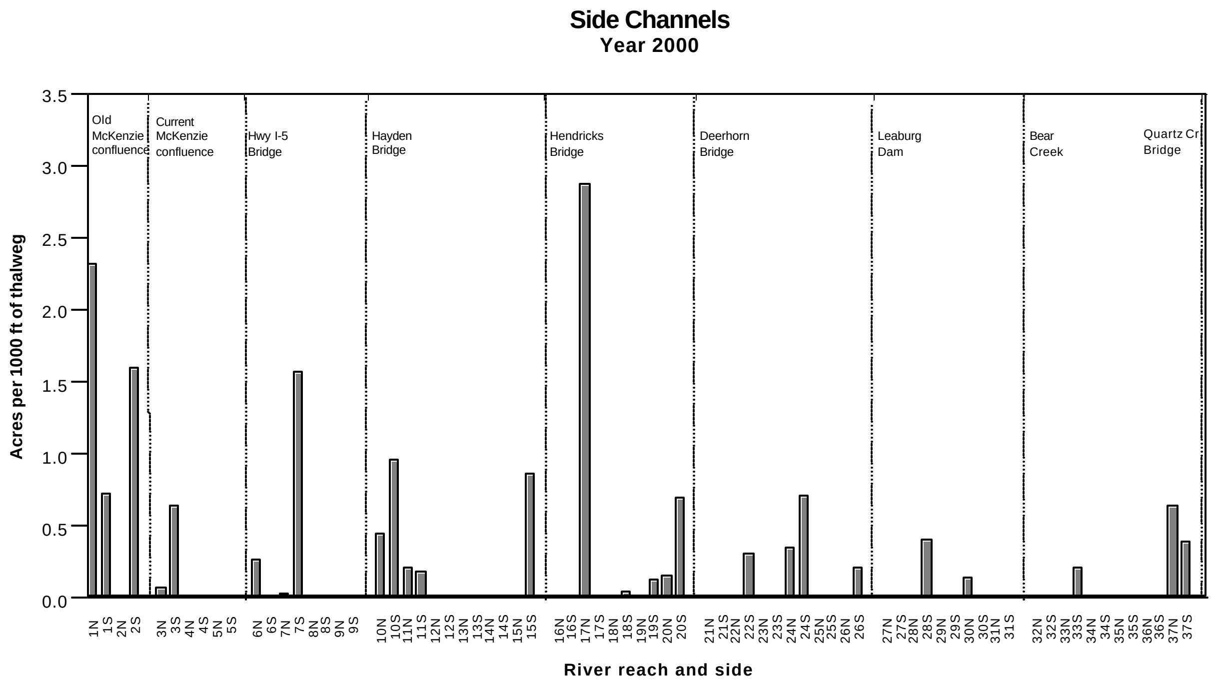


Figure 2-18. Alcove area (acres per 1000 ft of reach thalweg) by river reach and side. Top graph is for 2000 and bottom graph is for 1944. An "N" indicates the north side of the river and an "S" indicates the south side of the river.



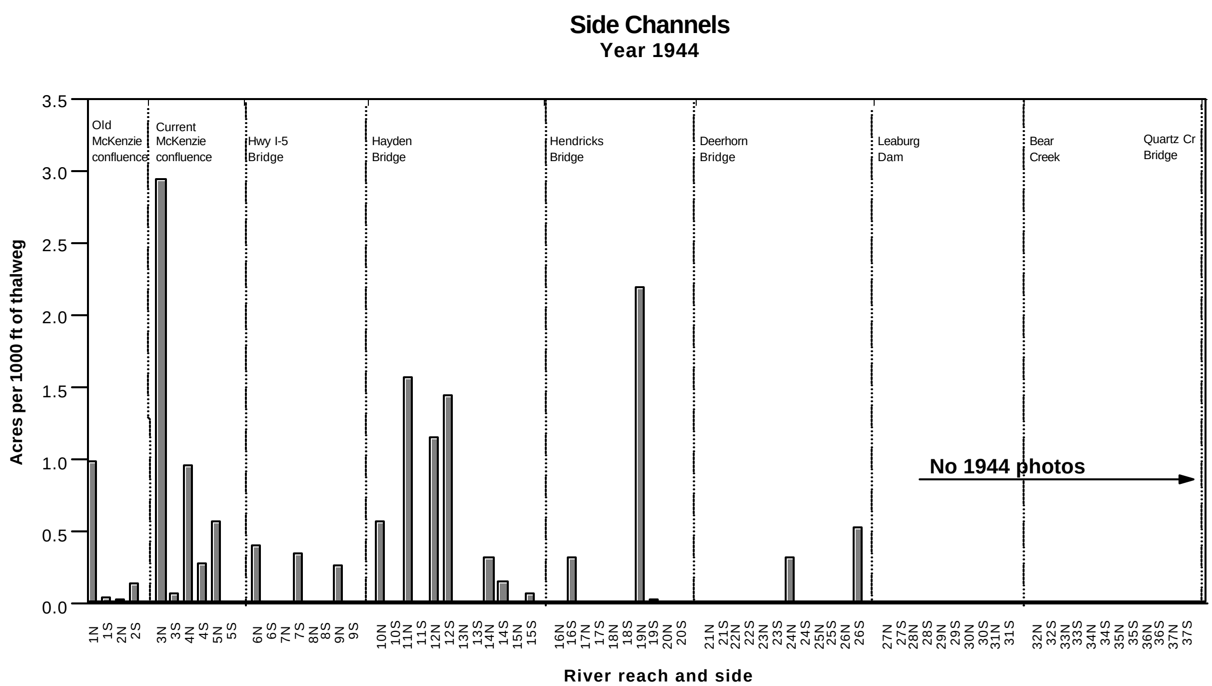
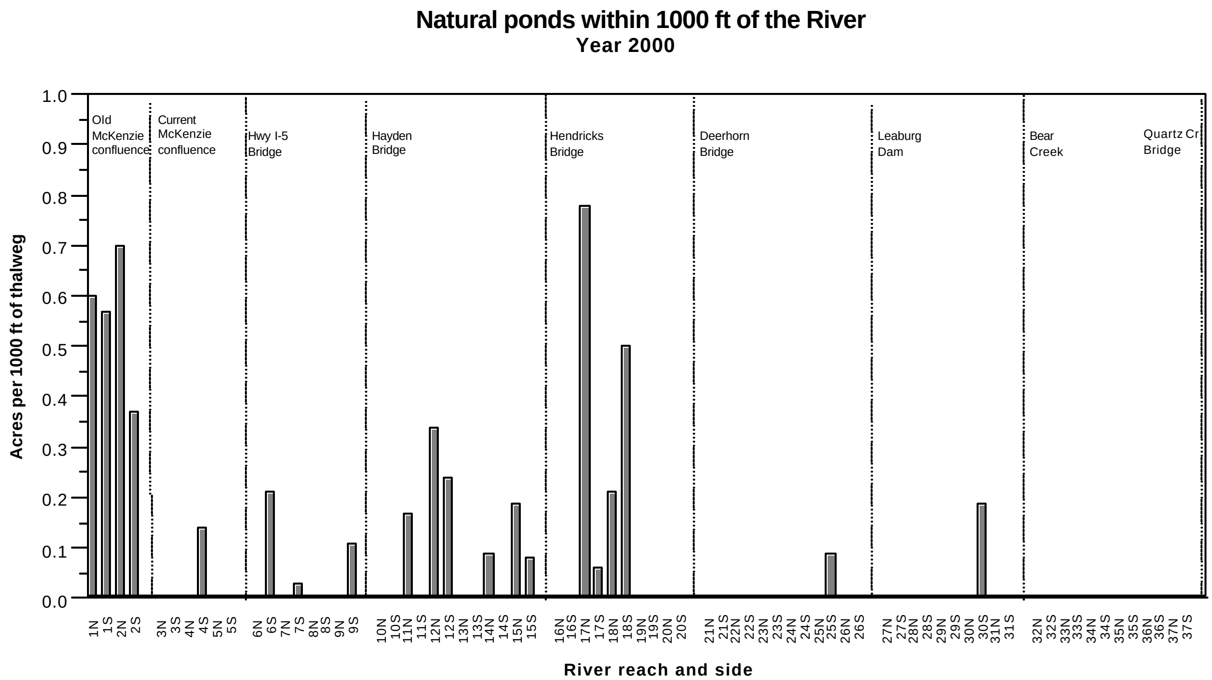


Figure 2-19. Side channel area (acres per 1000 ft of reach thalweg) by river reach and side. Top graph is for 2000 and bottom graph is for 1944. An “N” indicates the north side of the river and an “S” indicates the south side of the river.



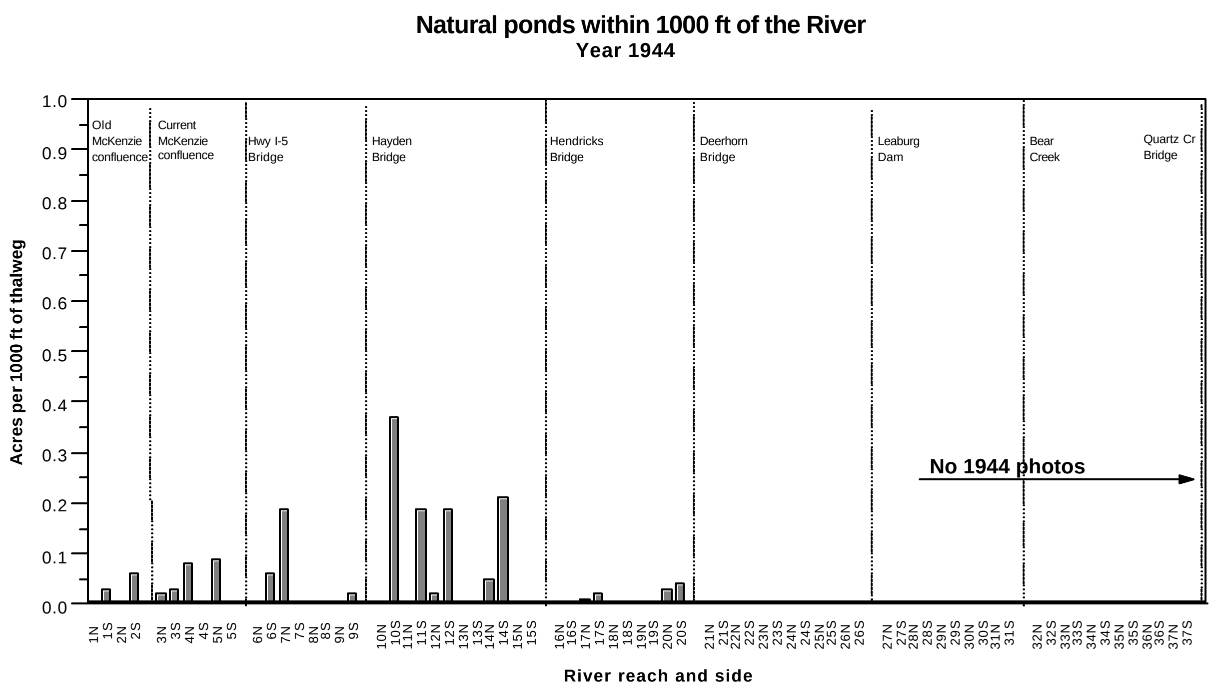
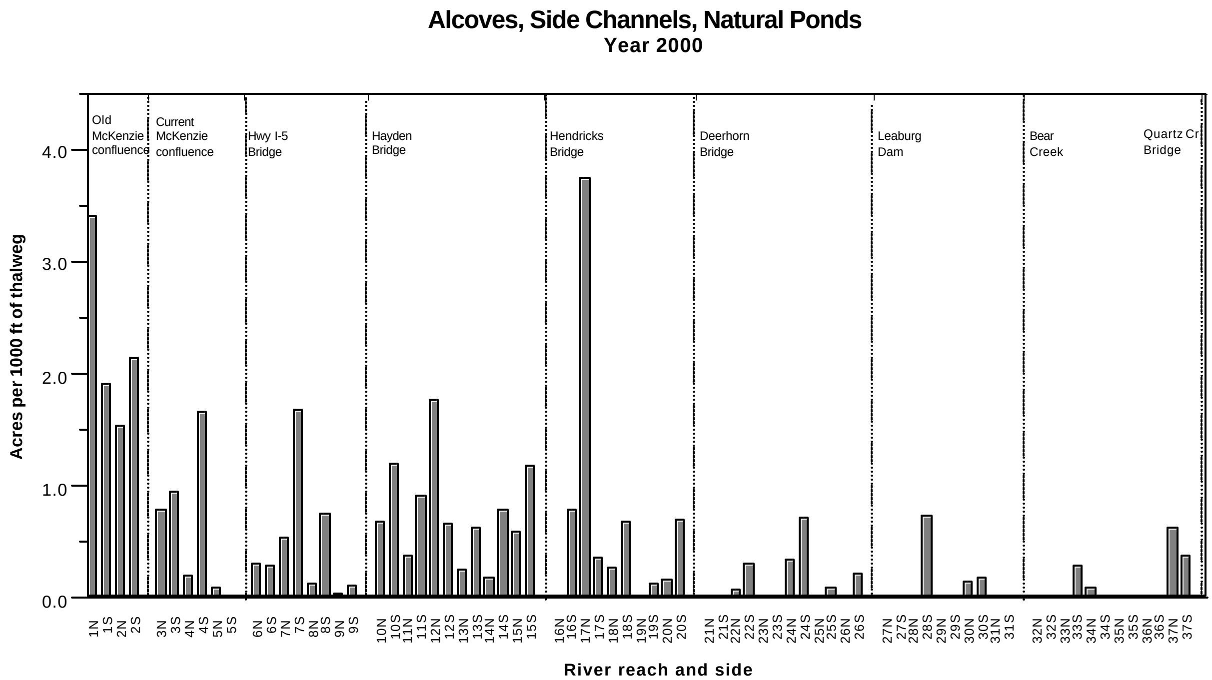


Figure 2-20. Natural pond area (acres per 1000 ft of reach thalweg) by river reach and side. Top graph is for 2000 and bottom graph is for 1944. Top graph is for 2000 and bottom graph is for 1944. An “N” indicates the north side of the river and an “S” indicates the south side of the river. Only ponds or portions of pond within 1000 feet of the river were included.



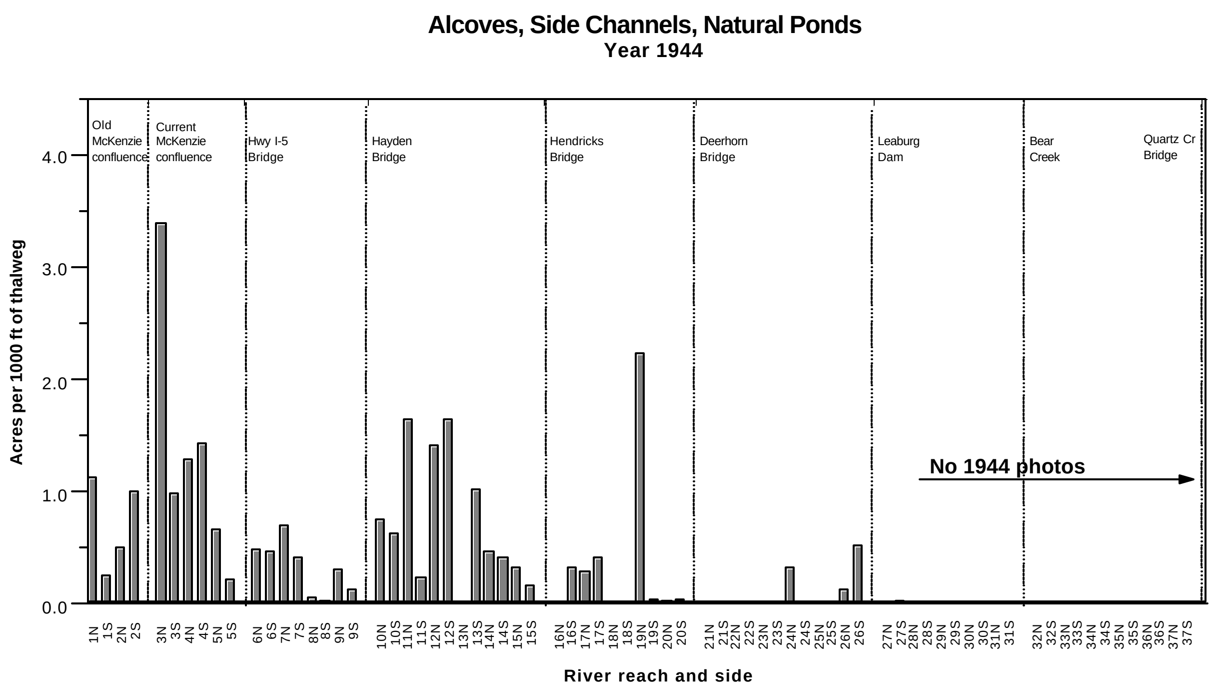
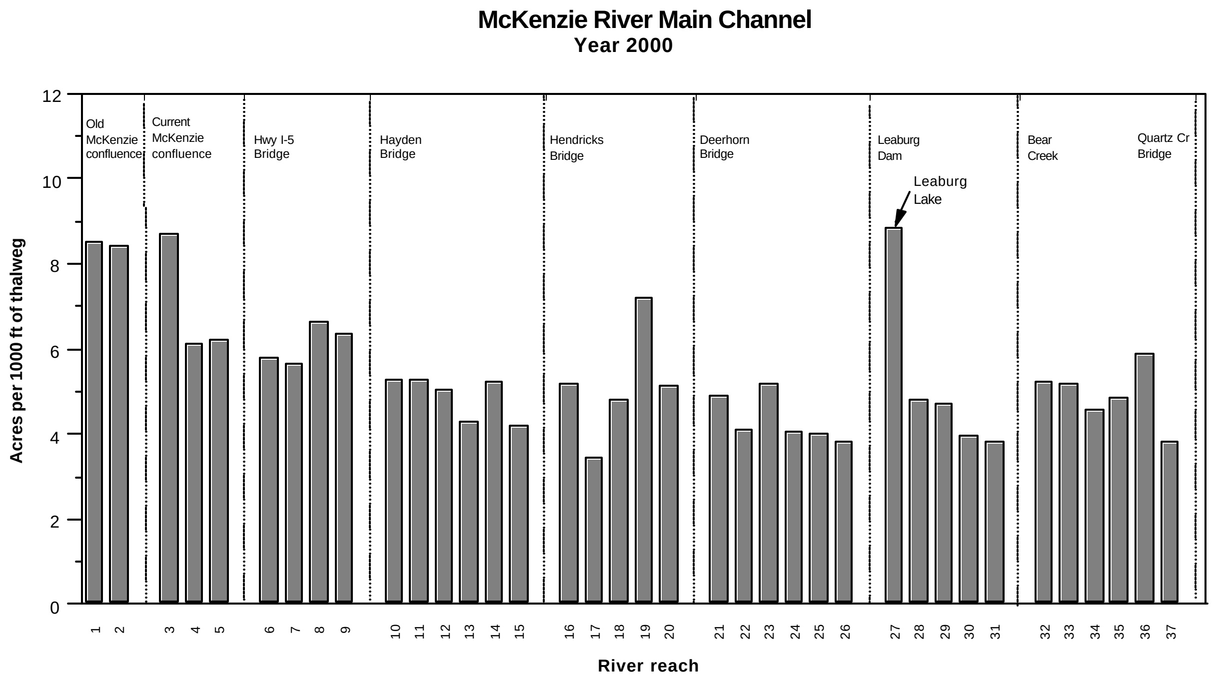


Figure 2-21. Combined area of alcoves, side channels, and natural ponds (acres per 1000 ft of reach thalweg) by river reach and side. Top graph is for 2000 and bottom graph is for 1944. An “N” indicates the north side of the river and an “S” indicates the south side of the river.



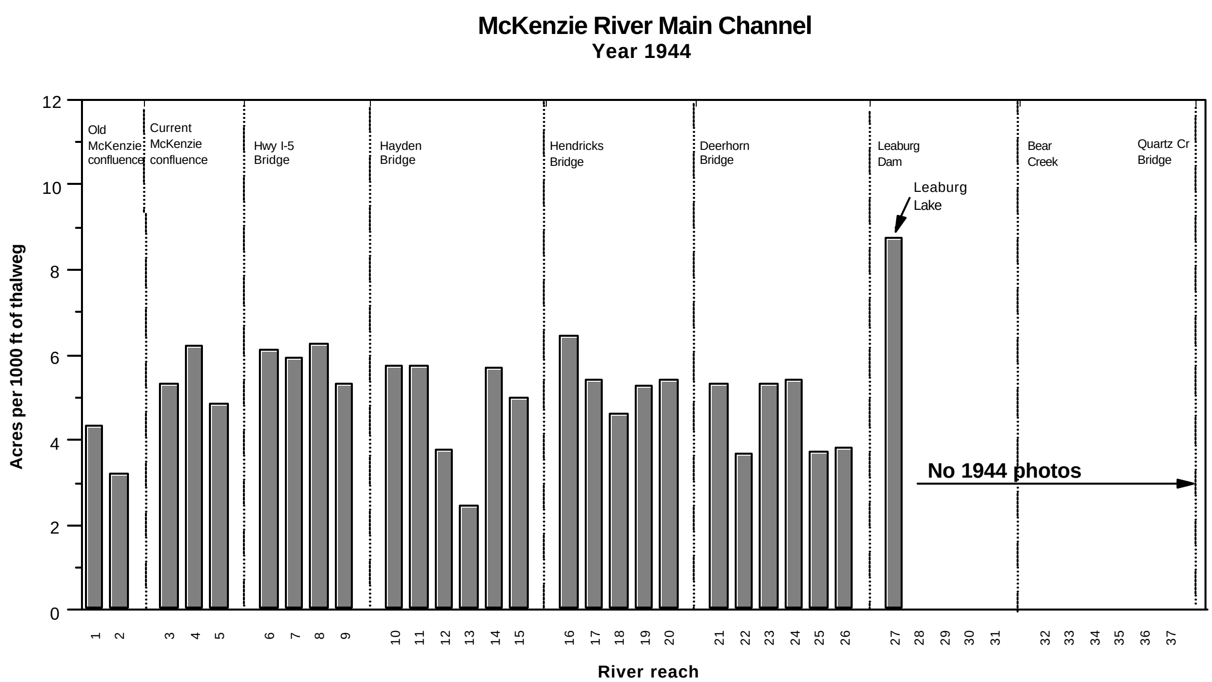
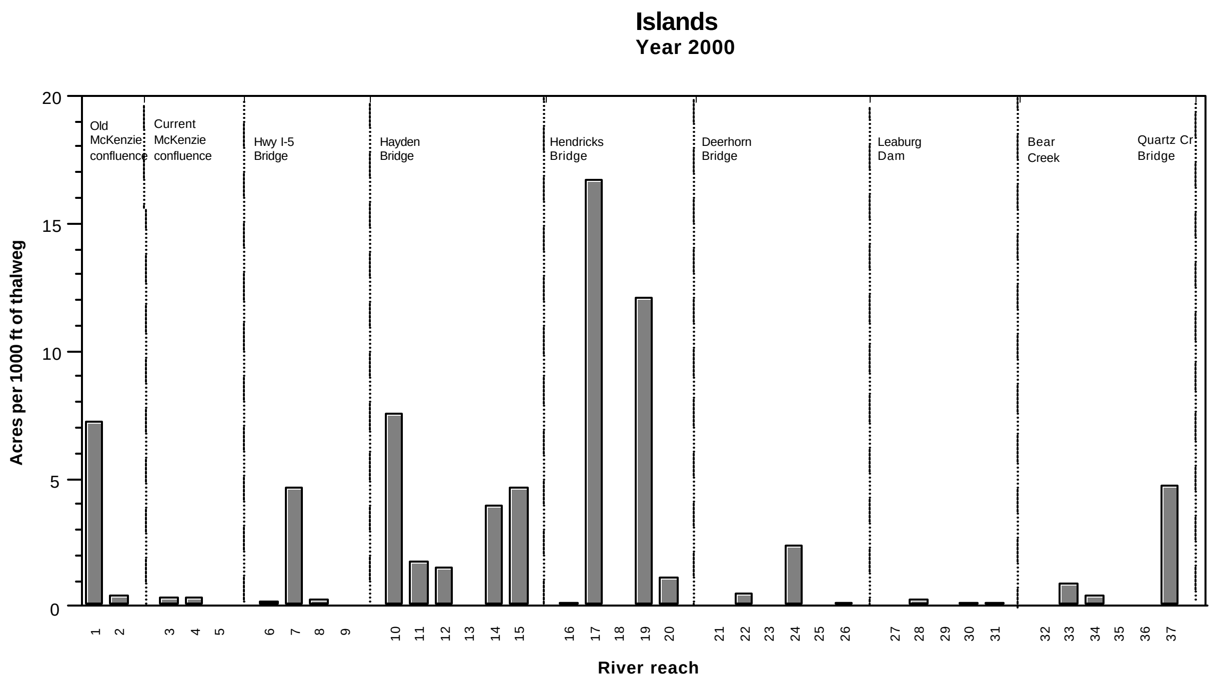


Figure 2-22. Area of main channel (acres per 1000 ft of reach thalweg) by river reach and side. Top graph is for 2000 and bottom graph is for 1944. An “N” indicates the north side of the river and an “S” indicates the south side of the river.



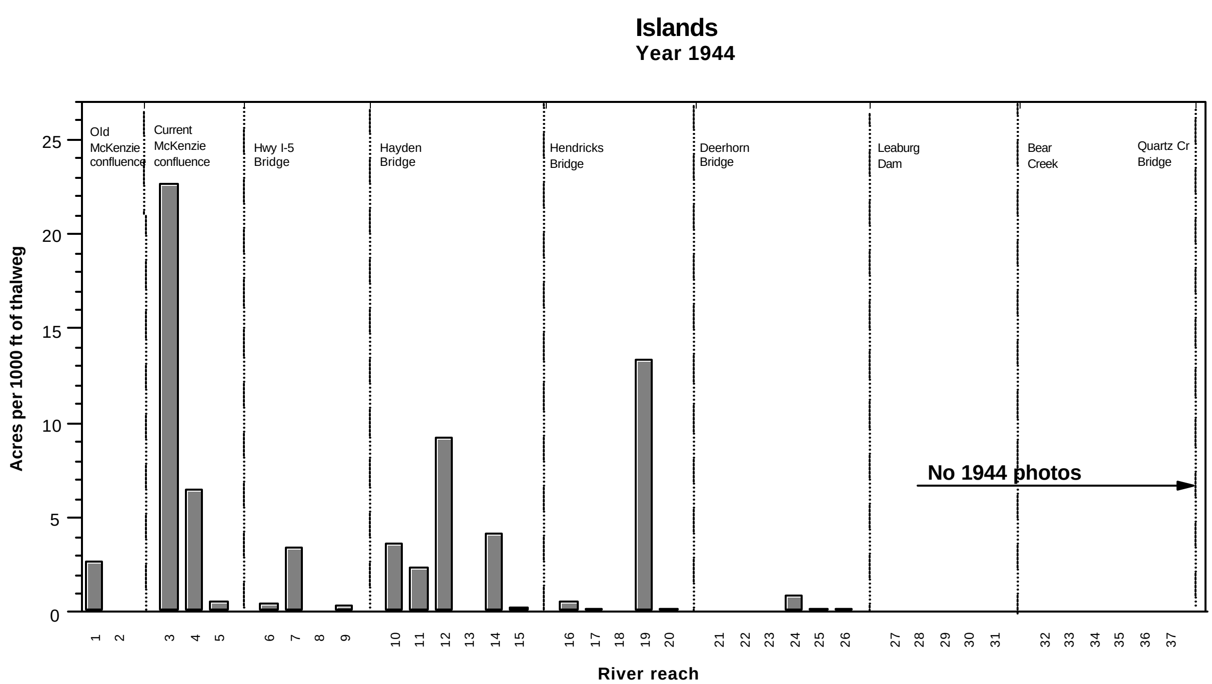


Figure 2-23. Area of islands (acres per 1000 ft of reach thalweg) by river reach. Top graph is for 2000 and bottom graph is for 1944. An "N" indicates the north side of the river and an "S" indicates the south side of the river.

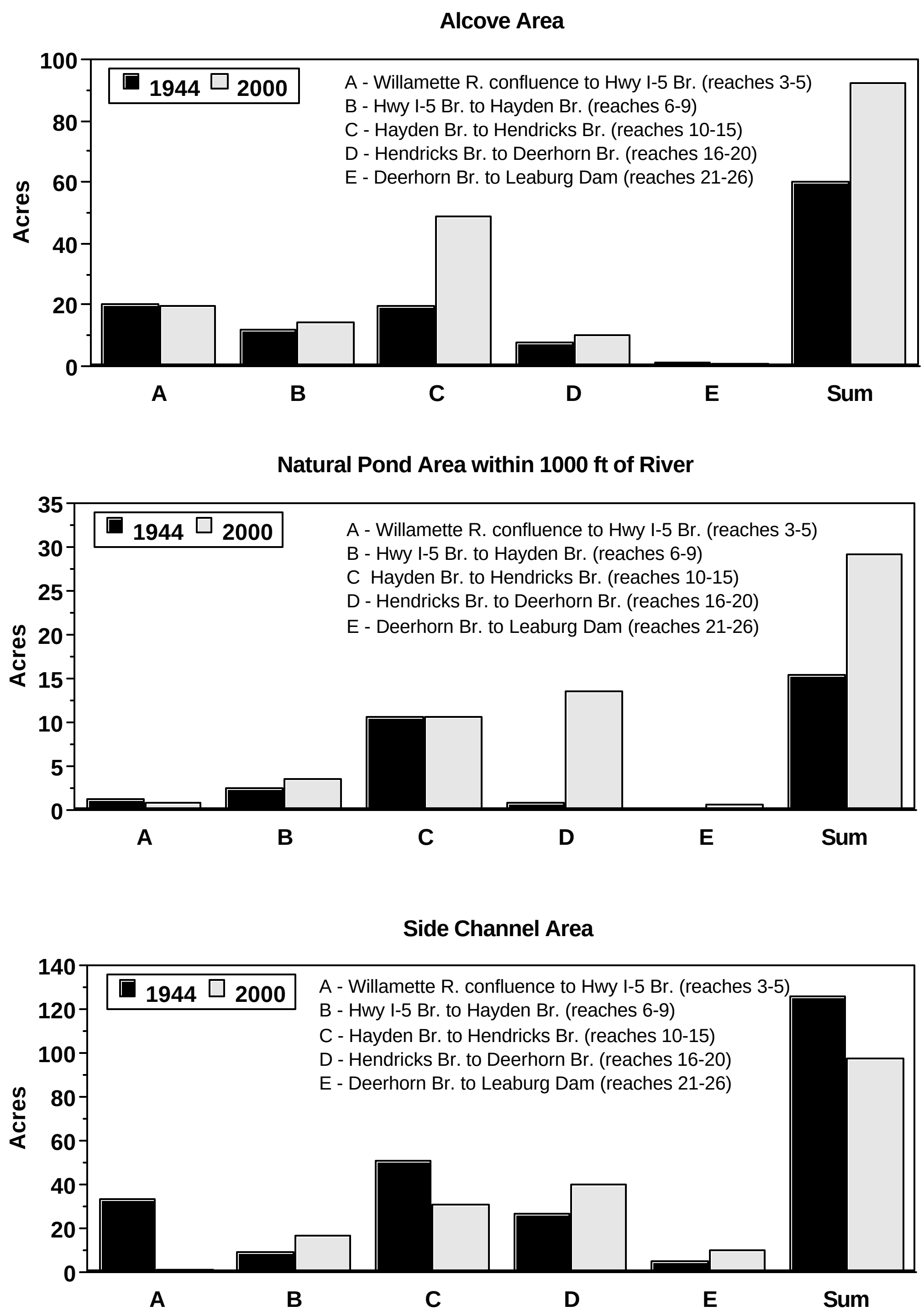


Figure 2-24a. Summary comparison for the area of alcoves, ponds, and side channels in 1944 and 2000 for the McKenzie River.

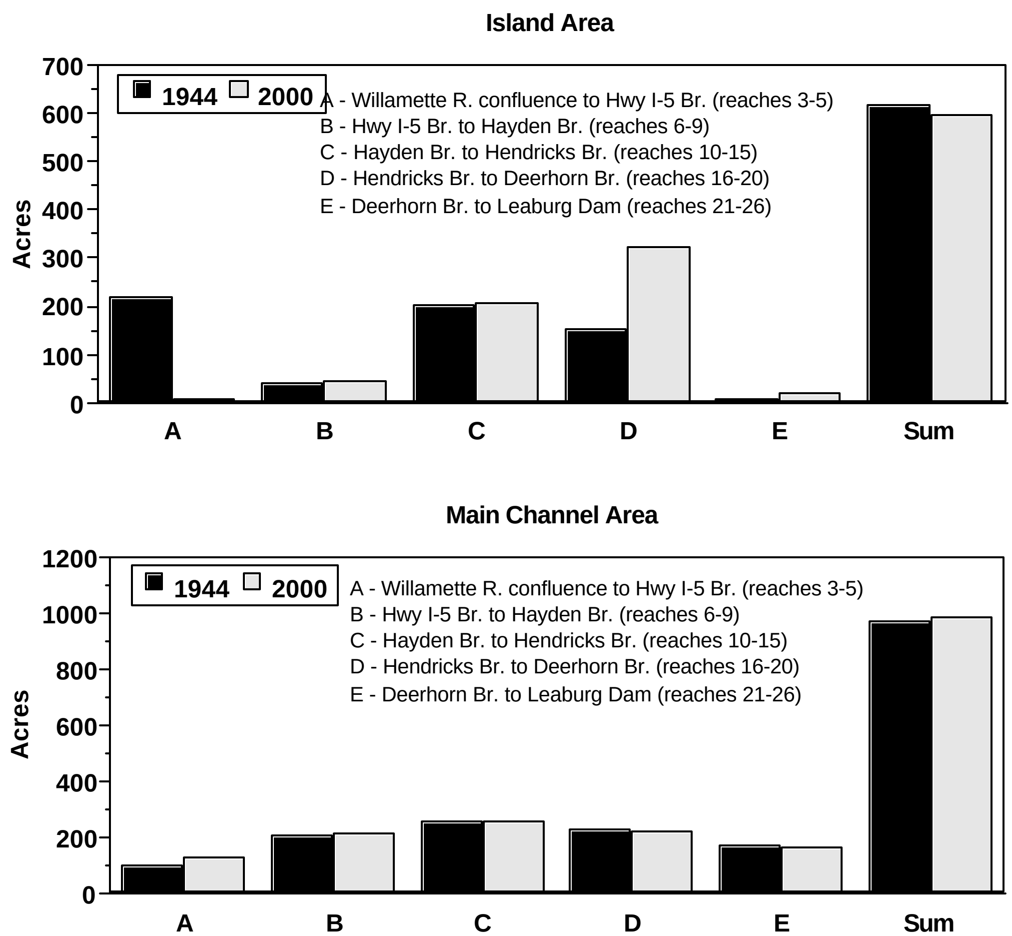


Figure 2-24b. Summary comparison for the area of islands and the main channel for 1944 and 2000.

Bank hardening

We conducted a boat survey of the McKenzie River study area and mapped sections of bank that were lined with riprap. Riprap usually consisted of basalt boulders from 1 to 3 feet in diameter, although some riprap adjacent to gravel mining areas near the mouth of the McKenzie included concrete rubble.

Riprap is a concern for aquatic ecosystems because it offers little useful habitat to most species of native fish (Andrus et al. 2000), especially during higher flows, and it often causes the river to become narrow and carve a deep trench against the riprapped bank. A highly riprapped reach of river is no longer capable of meandering which then causes the river to cut downward to expend its energy. This can lead to a coarsening of the bedload and an entrenched channel.

Most of the banks along the McKenzie River have no riprap. 13% of banks are riprapped in the lower half of the study area while only 0.3% are in the upper half. Riprap is most common downstream of the I-5 bridge, due to the gravel operations. Riprap is also common in reaches downstream of Hendricks Bridge, especially along the south bank within Springfield.

Most riprap along the McKenzie River was placed decades ago, a time when the Corps of Engineers fully funded these projects. Currently, riprap placement requires matching funds from the landowner and is subject to review by the National Marine Fisheries Service, Corps of Engineers, U.S. Fish and Wildlife, Oregon Department of Fish and Wildlife, Division of State Lands, and Lane County.

We noticed among newer riverfront homes in the lower river that riprap placement intended to protect the river bank in front of the house was common. Riprap is nearly absent upstream of Deerhorn Bridge. Here, the valley is narrower and the river is more confined by steep slopes. We were not able to determine where the river had riprap in 1944 using the aerial photographs.

Unless current federal, state, and county regulations change, the expansion of riprapped banks along the McKenzie River will probably continue at its current pace. There also may be additional riprap placed along the banks in the gravel extraction area downstream of the Hwy I-5 bridge. It is unclear how new 4d rules by the National Marine Fisheries Service for chinook salmon in the McKenzie River will influence future permitting of riprap projects.

Riparian vegetation and land use

The vegetation and land use next to the McKenzie River influences biotic process in the river. Although the McKenzie River is wide, tall riparian trees cast some shade along the river margins and help keep the river from warming. Riparian trees that fall into the river create preferred local habitat for fish or, when floated downstream and incorporated into large jams, help form side channels, islands, and other features. Streamside trees also drop leaves, needles, and branches into the river, which helps incorporate nutrients and carbon to the system. Since salmon no longer spawn in large numbers within the McKenzie River, nutrients and protein incorporated into salmon carcasses are no longer available for uptake by aquatic organisms and by other fish (Bilby et al. 1998). This places even more emphasis on nutrient and carbon supplies from terrestrial sources.

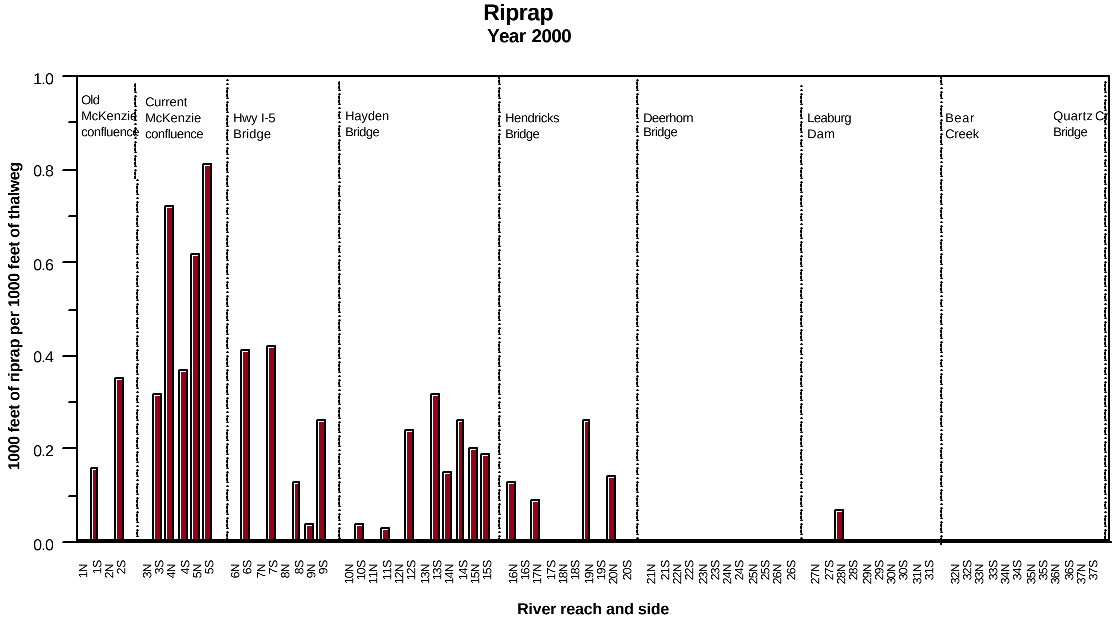


Figure 2-25. Riprap length (1000 feet of riprap per 1000 ft of thalweg) by river reach and side. An “N” indicates the north side of the river and an “S” indicates the south side of the river.

We delineated riparian vegetation and other land types within 500 feet of the McKenzie River using aerial photographs. This 500-foot-wide buffer wrapped around side channels and alcoves. Total area per reach was converted to acres per 1000 feet of thalweg in a reach so that reach values could be compared. Values for north and south sides of a reach (defined by the thalweg) were tallied separately.

We established vegetation and land use classifications, making sure that these classes could be identified in the1:24000 true color aerial photographs taken in 2000 and the 1:10000 black and white aerial photographs taken in 1944. We made field visits to selected areas helped ensure classification accuracy.

Conifer stands of three age classes (15-39 years, 40-79 years, and 80 years or more) and recent clearcuts (0-14 years old and presumably re-planted with conifers) are shown in Figure 43. Conifers are scarce along the McKenzie River downstream of Deerhorn Bridge and include only trees less than 80 years old. Conifers greater than 80 years old are found mostly on federal land and were located upstream of reach #28, which is located halfway between Leaburg Dam and Bear Creek.

In 1944, conifer stands were also scarce in the downstream portion of the river, except at the confluence where some large islands had remnant stands of old-growth Douglas-fir. Upstream of Hendricks Bridge, conifer stands greater than 40 years old were more abundant in 1944 than they are today (Figure 2-26).

Clearcuts within 500 feet of the river occur mainly in two reaches immediately upstream of Deerhorn Bridge and within reach #35, which is located downstream of Quartz Creek. All clearcuts have a band of trees ranging from 100 to 300 feet wide between the river and the clearcut boundary.   Visual observation during field studies determined that conifer stands less than 80 years old have very few snags. Most snags we saw were in stands greater than 150 years old.

Streamside willows are present mostly in the lower one-third of the study area (Figure 2-28). They usually coincide with cobble bars on the inside portions of river bends where high water occasionally scours out other vegetation. Willows are also often found growing along abandoned channels in broad flood plains.

Downstream of Hayden Bridge, willows are now more abundant than they were in 1944. In this lower-gradient segment it is likely that dampened peak flows have allowed willows to occupy areas that were once kept bare by the floods. Young hardwood trees (15-39 years old) growing within 500 feet of the river were common throughout most of the study area, with the highest values located downstream of Deerhorn Bridge (Figure 2-28). In contrast, hardwood trees greater than 40 years old within 500 feet of the river were relatively scarce. The scarcity of older hardwoods near the river may be partly a result of extensive hardwood uprooting in a large flood 35 years ago (1965). The dampening by reservoirs of peak flows since then is probably the reason that hardwoods now occupy the old flood plain.

Hardwood area was greater in 1944 than it is today. Most hardwood stands today are less than 40 years old, while a range of stand ages existed in 1944 (Figure 2-28). Willow and hardwood abundance is greatest between Hendricks Bridge and Hayden Bridge and along the Willamette River between the current confluence and the old confluence. Both of these segments have flood-prone land next to the channel which prevents areas supporting hardwoods from being converted to farm land or house sites.

Gravel and cobble bars without permanent vegetation are now found mostly between Hendricks Bridge and Hayden Bridge and downstream (and immediately upstream) of the Hwy I-5 bridge (Figure 2-29). Due to the low channel gradient in these two sections, the bedload tends to settle out and accumulate along the river. Not surprising, commercial gravel extraction pits in the McKenzie basin exist along in only these two sections of the main channel. Bare substrate was more common in 1944 than today, especially upstream of Hendricks Bridge (Figure 2-29, Figure 2-26). The scarcity of bare substrate today is probably due to the lack of high flows that scour out trees and, possibly, the presence of reed canary-grass; a dense exotic plant which tends to occupy a fringe of land near the river’s edge.

Cultivated fields and orchards are common within 500 feet of the river for most of the study area (Figure 2-29). Consistently higher densities of farm land near the river occur between Hendricks Bridge and Hayden Bridge. Grass seed is the most common cultivated crop along the McKenzie and most of the orchards are filberts. In 1944, fields and orchards were about twice as abundant as they are today. Areas of grass and brush (mostly overgrown pasture) are a minor component of the land along the McKenzie River. The exception is reach #17 that includes McNutt Island. This large island has been cleared of most trees and has extensive pasture and grass seed or hay fields. In 1944, grass and brush within 500 feet of the river was more common than it is today. Cattle grazing was more common then than now.

The area of urban residential and industrial/business use is high only along the south bank of reach #10. Here, several dozen houses within the city limits are perched above a riprapped bank on the outer bend of the river. Urban residential areas did not encroach upon the McKenzie River in 1944.

Rural residential land next to the river is common upstream of Hendricks Bridge (Figure 2-28). Here, the river banks are somewhat less flood-prone, the river meanders less, and the river takes on a wilder look. In 1944, very few houses were located within 500 feet of the river due to the flood hazard.

In the future, riparian land use and vegetation will probably continue on its current trajectory. Now dominated by young hardwoods, these trees will continue to grow without much disturbance from flood or fire. The relative low economic value of the hardwoods means that few will be harvested. Disturbance of these hardwoods will probably be limited to riverfront house sites and new recreation areas. Riparian conifers will probably decline over time since most existing stands are over 40 years and few new conifers are reproducing. Re-establishing conifer stands along the river will need to involve intentional planting preceded by pre and post control of competing reed canarygrass and other vegetation.

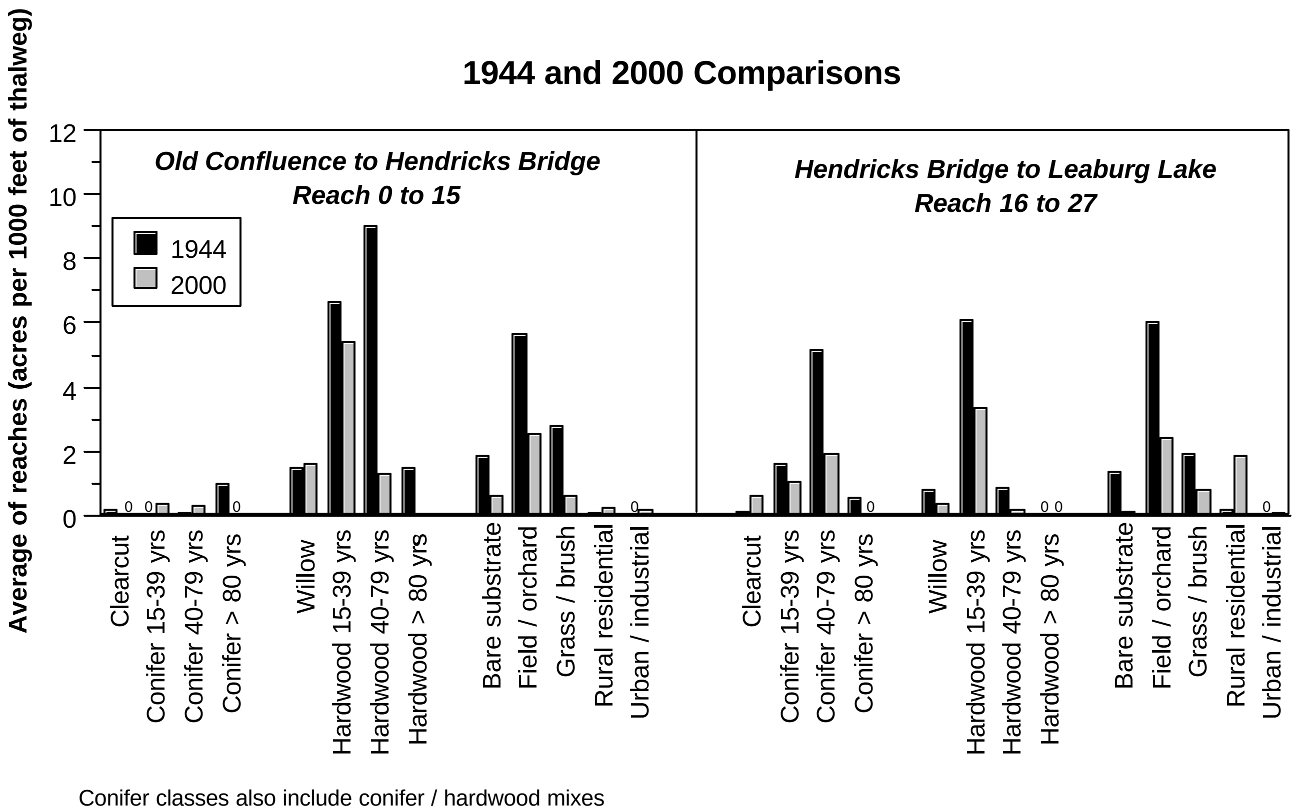


Figure 2-26. A comparison of 1944 and 2000 vegetation and land use within 500 feet of the river.

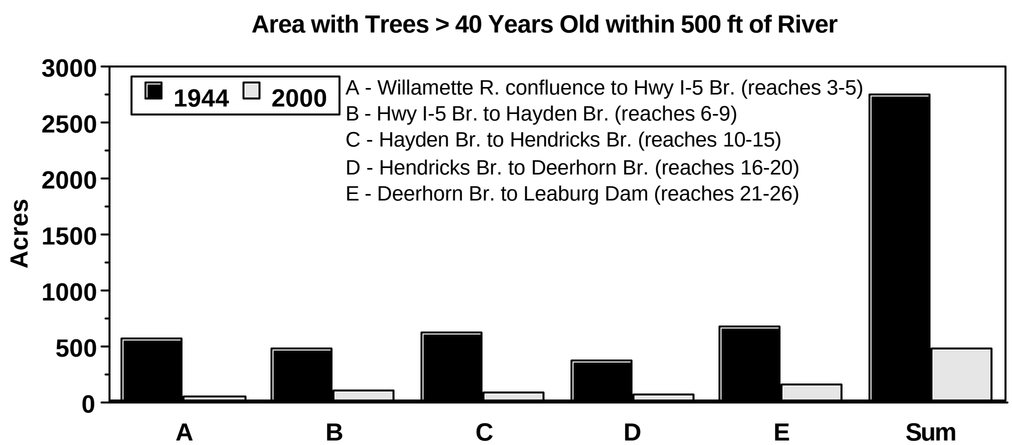
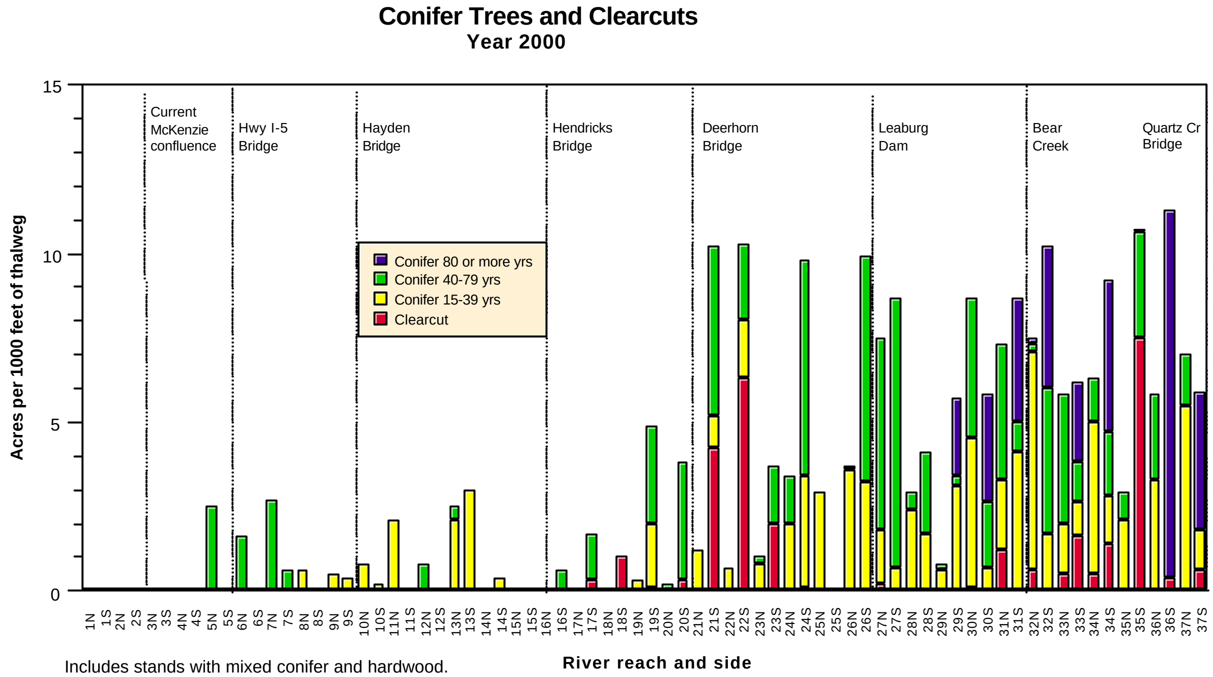


Figure 2-26a. A comparison of 1944 and 2000 vegetation consisting of trees older than 40 years and growing 500 feet of the river.



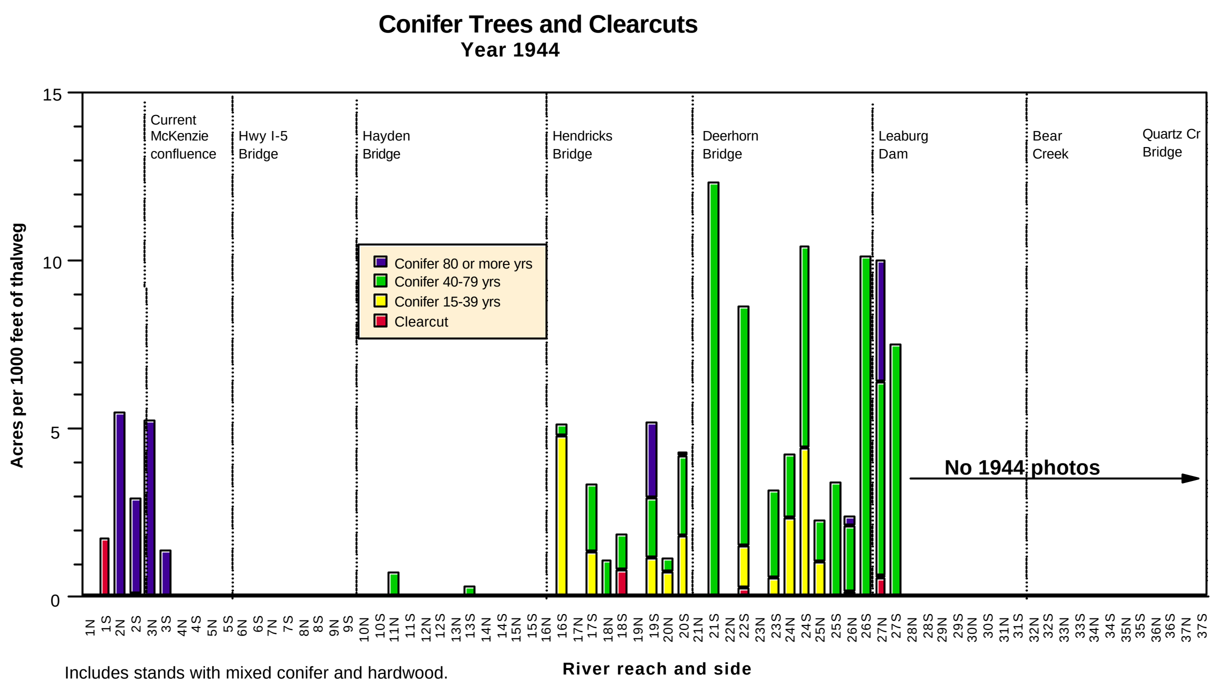
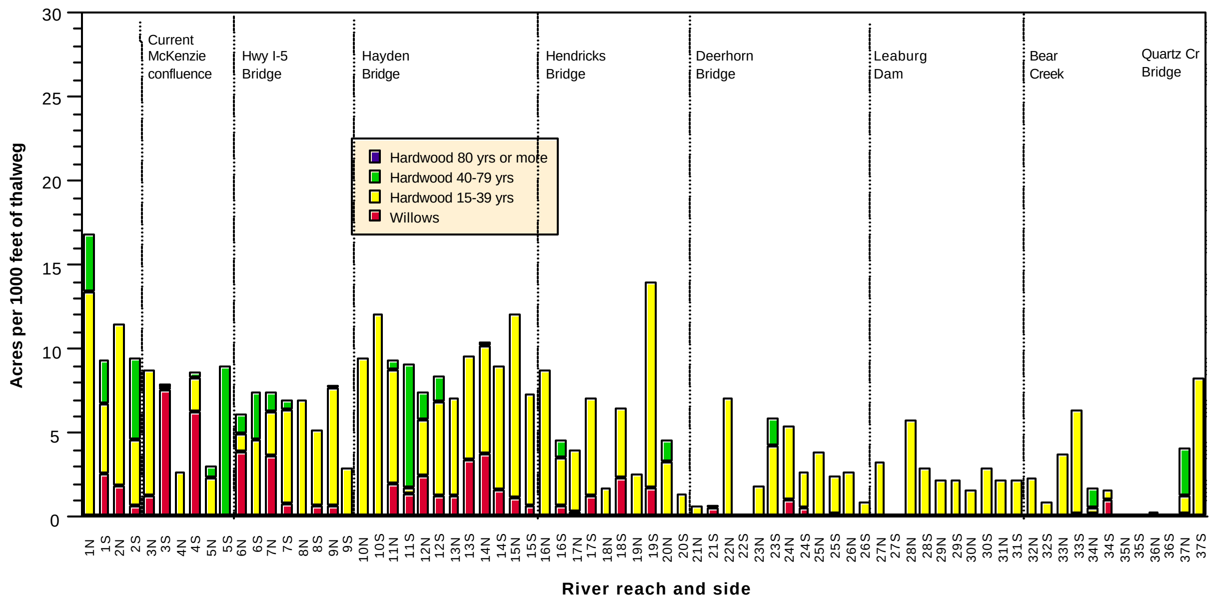


Figure 2-27. Area (acres per 1000 feet of thalweg) for conifer riparian trees and recent clearcuts (0-14 years old) within 500 feet of the river, by reach. Includes stands that are a mix of conifers and hardwoods.

Willows and Hardwood Trees
Year 2000



Willows and Hardwood Trees
Year 1944

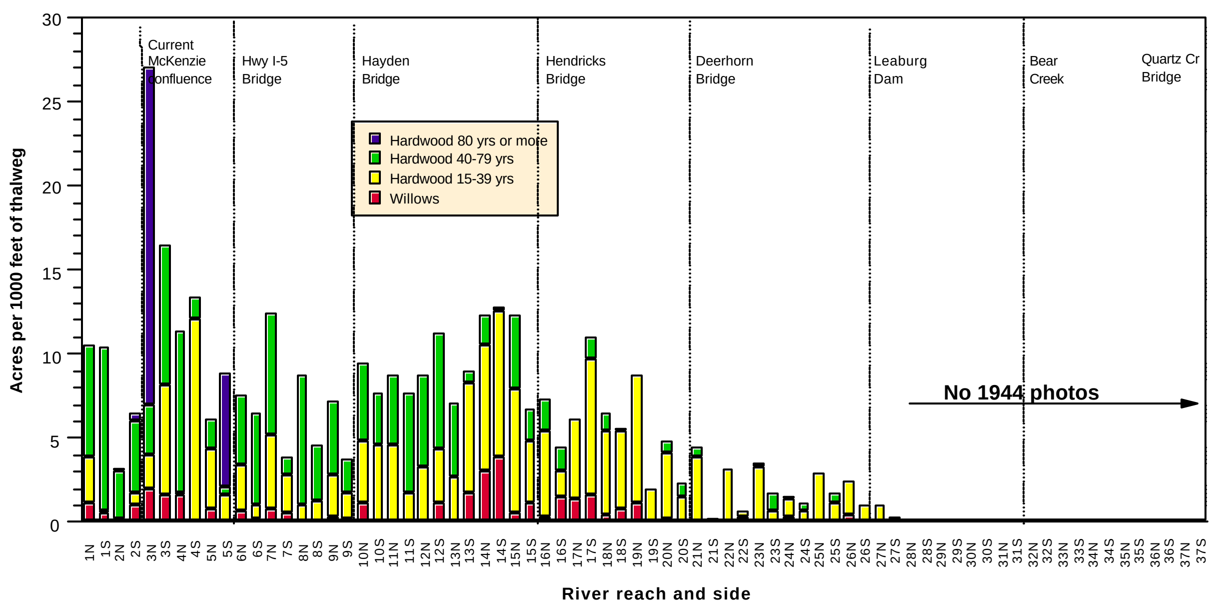
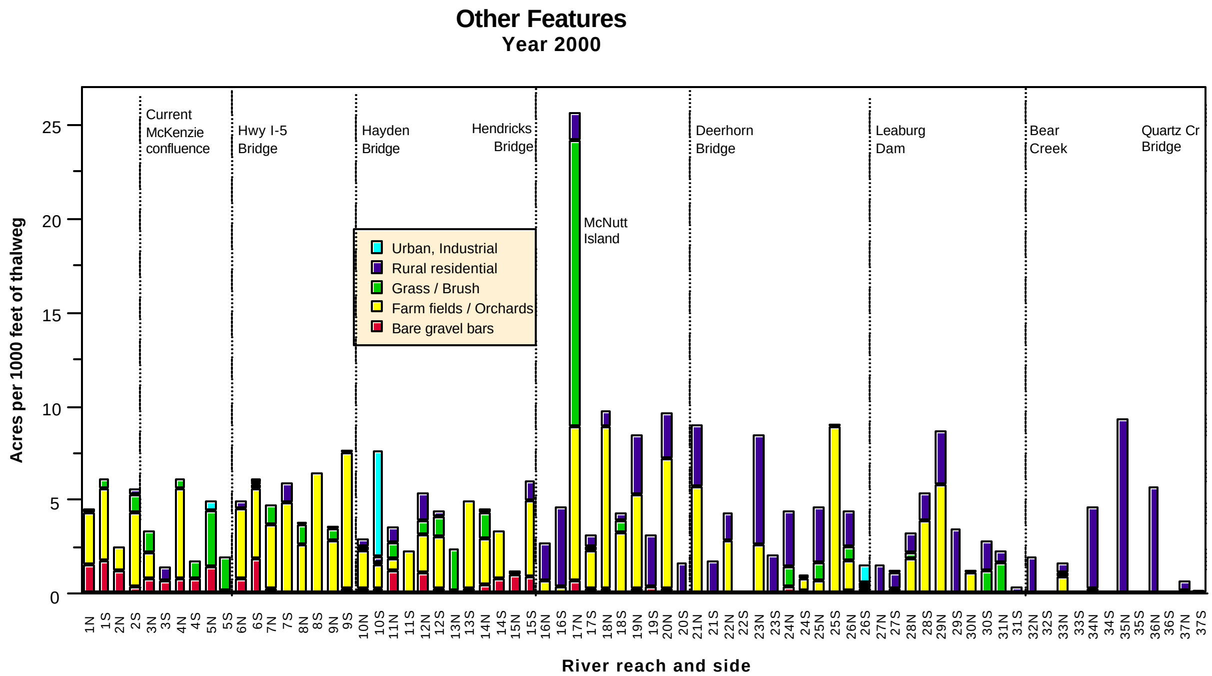


Figure 2-28. Area (acres per 1000 feet of thalweg) for willows and hardwood trees within 500 feet of the river, by reach.



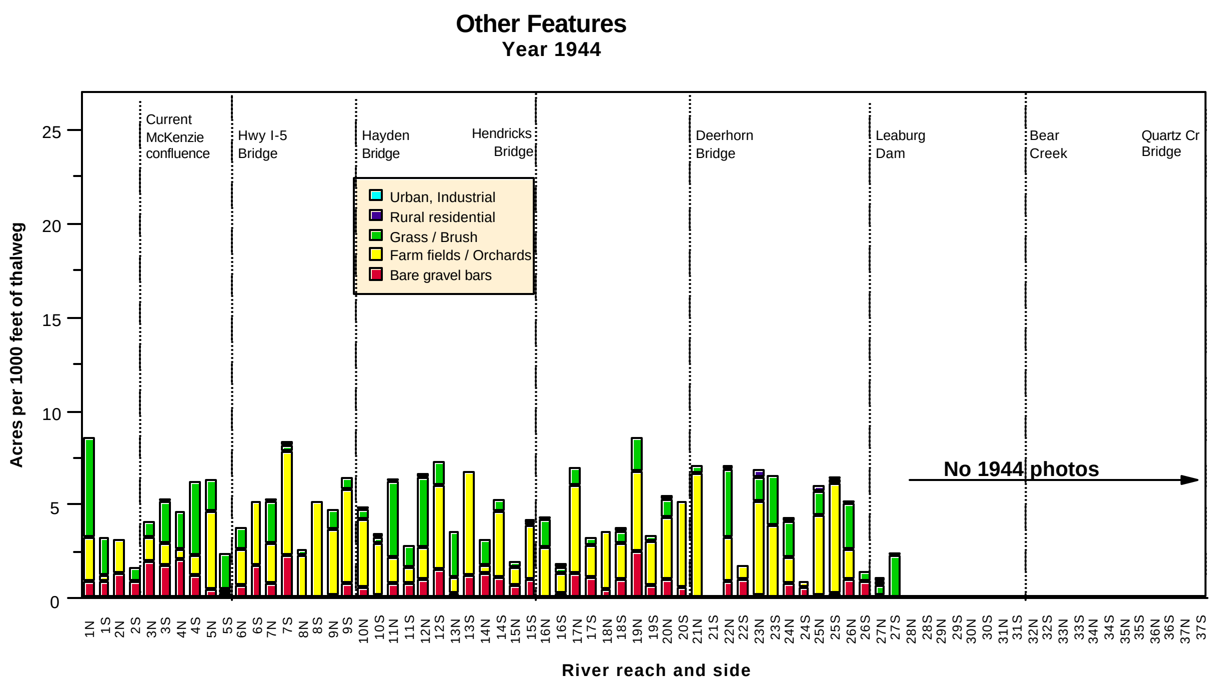


Figure 2-29. Area (acres per 1000 feet of thalweg) for bare gravel in the flood plain, fields/orchards, grass/brush, rural residential, and urban/industrial within 500 feet of the river, by reach.

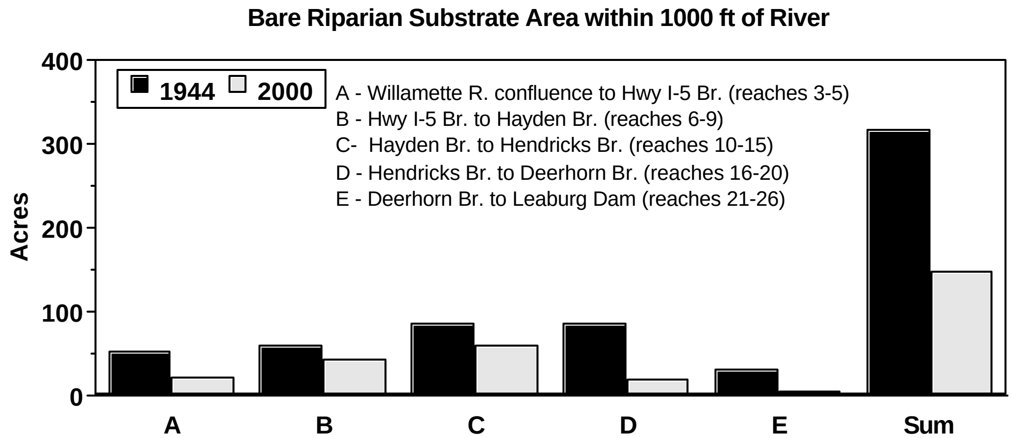


Figure 2-30. Area of bare gravel and cobble in the flood plain by segment for 1944 and 2000.

Riverfront houses

Riverfront development can interfere with ecological processes in the river. For example, the removal of large trees to make room for houses and other infrastructure reduces the shade, litter fall, and large wood that would normally enter the river. Reduced shade can reduce the area of cool water pockets on hot days, reduced litter fall can keep much-needed nutrients from entering the river, and without large logs the river preferred fish habitat such as log jams and log-initiated islands are less abundant.

With houses close to the river, there are more opportunities for spills of toxic materials to enter the river and fecal bacteria to leach into river when drain fields fail. Furthermore, the houses and their contents are more vulnerable to high flows.

We conducted a field inventory of riverfront houses to determine the extent of riverfront development, characteristics of these houses and adjacent river banks, and the ecological implications of the development.

The inventory extended from the Quartz Creek Bridge (Finn Rock) to the confluence of the old McKenzie River channel within the Willamette River. This is a channel distance of 54.3 miles. Because only two riverfront houses existed in the lower 7.2 miles of the study area, subsequent analysis was mainly of that portion of the McKenzie River upstream of the Highway I-5 Bridge.

We used a jet boat to inventory houses and other features downstream of Leaburg Dam and within Leaburg Lake. A whitewater raft was used to inventory that portion of the river from the Quartz Creek Bridge to the head of Leaburg

Lake. Several large islands downstream of Leaburg Dam split the main channel which required us to inventory houses and other features along each branch of the river main stem. No houses exist on the islands.

We used a GPS to determine the location of all houses that were within an estimated 500 feet of the edge of the main channel. Houses behind another riverfront house were not included. The GPS location was usually near the centerline of the main at right angles to the house. Notes were kept to indicate whether the house was on the north (right side facing downstream) or the south side of the river.

The inventory upstream of Leaburg Lake was conducted in early August, 2000 and the remainder was done in late September, 2000. Since water levels were unusually low in September, 2000, we had difficulty getting the jet boat through shallow riffles. The boat operator was also operating the GPS and so some locations adjacent to riffles were not captured with great accuracy. However, house locations are usually within 100 feet of their true location. We gathered additional information on each house, including:

<u>Distance from the river</u> – Estimated distance from the wetted edge of the river (or its alcoves and side channels) to the side of the house or attached deck nearest the river.

<u>Value of house</u> – Estimated value of the house minus the land. Three broad categories were established: low value (less than $50,000), moderate value (between $50,000 and $150,000), and high value (greater than $150,000). Low value homes were typically older vacation cabins and manufactured homes. High value homes were typically larger and newer than the other houses.

<u>Landscaping</u> – The degree of disturbance of natural vegetation along the river, especially of that area between the house and the river. Three broad categories were established: mostly undisturbed, intermediate, and disturbed. "Mostly undisturbed" meant that a majority of riverfront trees were still intact and that there was a dense understory of native species. Typically, houses were painted to blend in with the vegetation. "Disturbed" landscaping meant that most of the trees and understory had been removed and replaced with lawn or urban-style gardens. These houses sometimes included private boat ramps and graded yards. Houses with intermediate landscaping had yard features that fell between the mostly undisturbed and disturbed.

<u>Likelihood of flooding</u> – The likelihood that a house would be inundated during a large flood (50-year event). Two categories were established: high likelihood of flooding and low likelihood of flooding. Houses with a high likelihood of flooding were those located on lower terraces near the river. The guide who rowed the raft in the portion of river between Quartz Creek Bridge and Leaburg Lake had rafted this section following the February, 1996 high flow (highest since

December, 1964). He provided us a perspective on high water marks. We also used the geometry of the channel and local terracing to make a determination of flood stage. The 1996 flow was a 100-year event (using a log-Pearson type III distribution) when calculated from post-reservoir records at the Vida streamflow gage (from 1968 to 1998). Yet, the flow was only a 3-year event for unregulated conditions that existed prior to construction of Cougar and Blue River Reservoirs (before 1963). A flood flow in December, 1964 was nearly twice that of the 1996 flow. Only Cougar Reservoir was constructed at that time and, had Blue River Reservoir been finished, the peak flow would have been reduced some. However, the flood dampening capacity of Cougar Reservoir is about twice that of Blue River Reservoir and so its additional capacity would not have been enough to significantly ease flooding. The ability of reservoir managers to control downstream flooding during extreme flows is limited. Consequently, we have assumed that the actual flood stage of a 50-year event was about 5 feet higher than the 1996 high flow (Figure 2-31). The flood danger categories we established do not take into account damage due to channel migration.

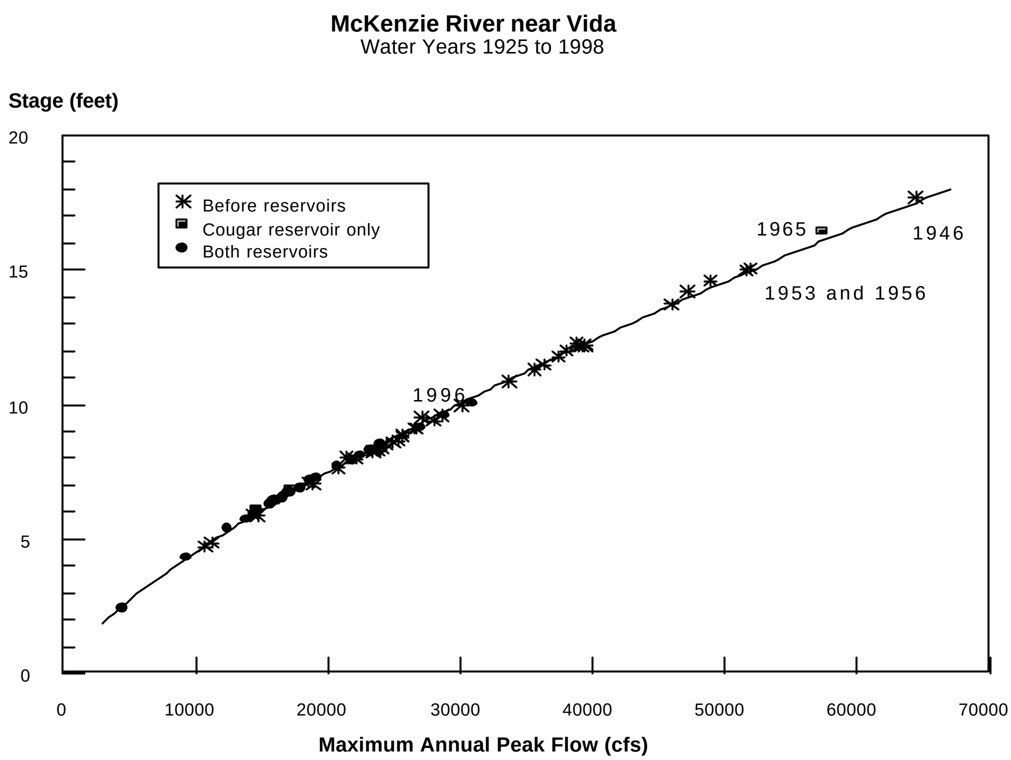
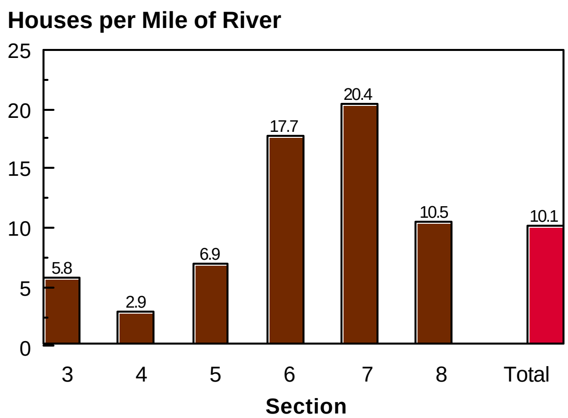


Figure 2-31. Maximum annual peak flow and stage for the McKenzie River near Vida between 1925 and 1998.

There are 466 riverfront houses along the McKenzie River between the Quartz Creek Bridge and the Hwy I-5 Bridge, with an average density of 10 houses per mile of river. Housing density varied considerably from a low of 3 houses per mile between Hayden Bridge and Hendricks Bridge to over 20 houses per mile between Leaburg Dam and Ben and Kay Dorris State Park (Figure 2-32). Upstream of the State Park, riverfront development rarely occurs on the south bank because it is private and public forest land and is limited on the north bank at spots where Highway 126 is close to the river. Development of riverfront land downstream of Deerhorn Bridge has not occurred where river banks are low due to the tendency of the river to meander across the broad valley.



3 = Hwy I-5 Bridge to Hayden Bridge
4 = Hayden Bridge to Hendricks Bridge
5 = Hendricks Bridge to Deerhorn Bridge
6 = Deerhorn Bridge to Leaburg Dam
7 = Leaburg Dam to (Pt. A) near Ben and Kay Dorris State Park
8 = Pt. A to Quartz Creek Bridge (Finn Rock)

Figure 2-32. McKenzie riverfront house density by reach from Hwy I-5 Bridge to Quartz Creek Bridge (Finn Rock).

Over one-third of the houses we inventoried were located within 100 feet of the low-flow channel edge and nearly three-quarters were located within 200 feet of the river (Figure 2-33). Only 8% were located a distance of 300 to 500 feet from the river. This was surprising since over 60% of all houses were rated as having a high likelihood of flooding during a 50-year flood event (Figure 2-34). Many houses could have been sited on less flood-prone land simply by locating them back further from the river. The most likely reason for siting houses so close to the river is to obtain a good view of the river.

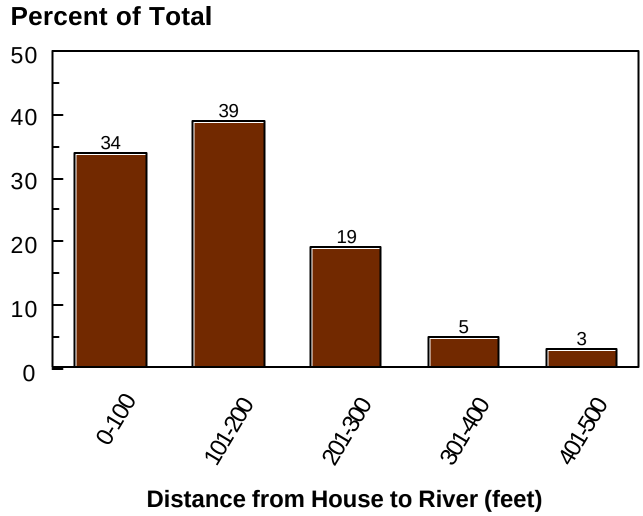


Figure 2-33. Location of riverfront houses relative to the river edge.

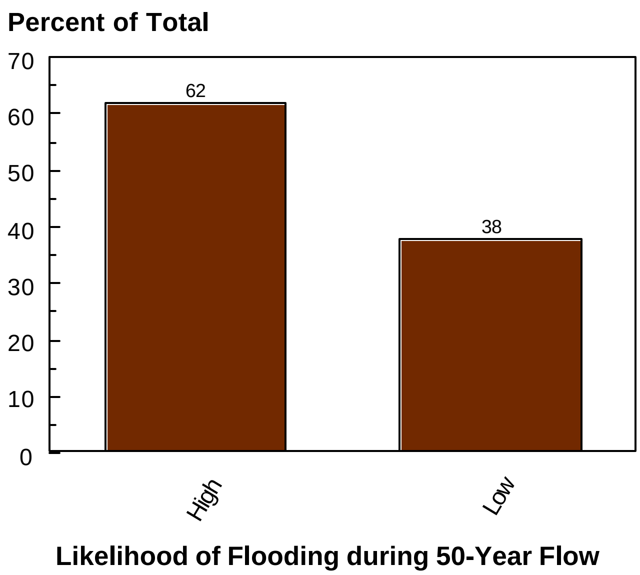


Figure 2-34. Percentage of riverfront houses having high and low potential of flooding during a 50-year flow.

Natural vegetation was rated as intermediate or disturbed at 85% of the house sites, with nearly half of these sites rated as disturbed (Figure 2-35). Presumably, trees and understory plants were removed in order to obtain a better view of the river and allow more sunlight to hit the house site.

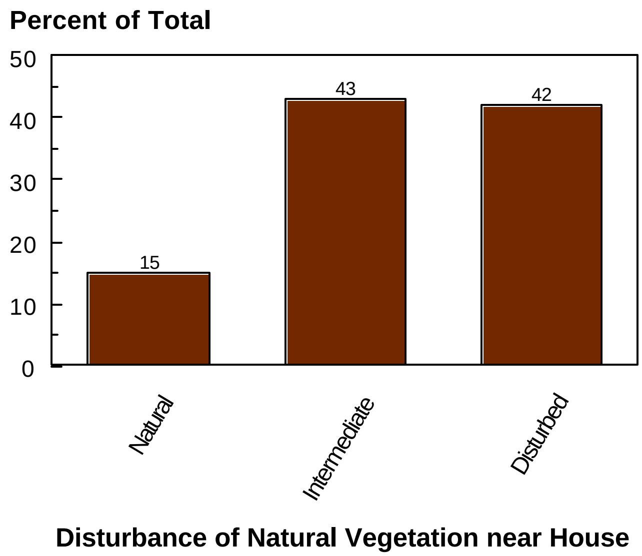


Figure 2-35. Percentage of riverfront houses for each of three riparian vegetation disturbance classes.

Lane County recently completed an inventory of vacant riverfront parcels of land along the McKenzie River within the study area. The inventory was based on permit activity records and post office address assignments kept by the County. The records indicate that there are a total of 223 vacant parcels (Figure 2-5). The zoning of these parcels includes non-resource lands such as rural residential, forest land, and agricultural land.

While some of the vacant land parcels are large enough to be split into two or more house sites under current zoning regulations, the majority of these larger parcels have their short dimension along the river. This limits opportunities to have all of the additional house sites at the edge of the river. Therefore, we have made the assumption that when these vacant parcels are developed the additional riverfront houses will not be much greater than the number of vacant parcels. Not all vacant parcels can be used as house sites. Some parcels are too low in the flood plain and others have no capability to handle a septic system.

Our inventory indicates that there are 474 riverfront houses along the McKenzie River within the study area and the County inventory indicates there are about 223 riverfront parcels that do not yet have houses. Assuming that most existing parcels have only one house, this means that about one-third (223/(474+223)) of the total riverfront parcels have not yet been developed. The percentage of vacant lots ranges from 18% between Deerhorn Bridge and Leaburg Dam to 60% between Hayden and Hendricks bridges (Table 2-5).

Table 2-5. McKenzie riverfront parcels and houses within the study area.

	Vacant Parcels	# of Existing Houses	Total	% Parcels Vacant
Highway I-5 Bridge				
	40	43	83	48
Hayden Bridge				
	42	28	70	60
Hendricks Bridge				
	37	50	87	43
Deerhorn Bridge				
	28	128	156	18
Leaburg Dam				
	44	136	180	24
Ben and Kay Dorris Park				
	32	89	121	26
Quartz Cr Bridge (Finn Rock)				
OVERALL	**223**	**474**	**697**	**32**

Riverfront development in the future will probably include new development on vacant parcels and house replacement (or remodeling and expansion) on developed parcels.

With one-third of remaining McKenzie riverfront parcels vacant and many older existing houses ready for re-development, there are several actions that might change current development practices along the river. One, is an educational program to perspective landowners and developers about the biological reasons for retaining natural vegetation and large wood along the river, flood risk, and proper sewage treatment. Secondly, an inventory of vacant parcels that are marginal building sites (due to risk of flooding or lack of sewage treatment opportunities) could be highlighted and considered high priority for purchase or inclusion in a land trust program.

Large wood in channels

Large wood in the river creates conditions favorable to fish. Wood is often used by aquatic insects as a stable substrate for feeding and attaching. The wood, either as jams or as single pieces, can change the morphology of the river by plugging within side channels and initiating islands (Abbe and Montgomery 1996). The microhabitat around trees (especially their root wads) can be direct habitat for fish (Harvey et al. 1999). Juvenile chinook salmon are particularly attracted to root wads where the close proximity of slow and fast water allows them to find refuge in the root wad and capture insects drifting downstream.

Between 1870 and 1911 nearly 400 large logs per mile of river (7.6 per 100 feet) were snagged out of the Willamette River from Eugene to Albany for purposes of promoting navigation (Sedell and Froggatt 1984). Such high levels of wood loading probably also existed in the McKenzie River at that time but we could find no quantitative historical accounts to confirm this. We examined aerial photographs from 1944 and 2000 in order to determine changes in the magnitude of wood loading in the McKenzie River over the last 56 years. Both single logs and log jams were tallied from Leaburg Dam to the mouth of the McKenzie River.

Currently, the number of single logs in the McKenzie River is only about 1 log per mile, while logs averaged only 2.4 logs per mile in 1944 (Figure 2-36). For both periods, logs were most abundant between Hendricks Bridge and Hayden Bridge, a reach that has lower than average channel gradient. Similarly, the current density of log jams averages only 0.1 jams per mile and only 0.25 jams per mile in 1944 (Figure 2-37).

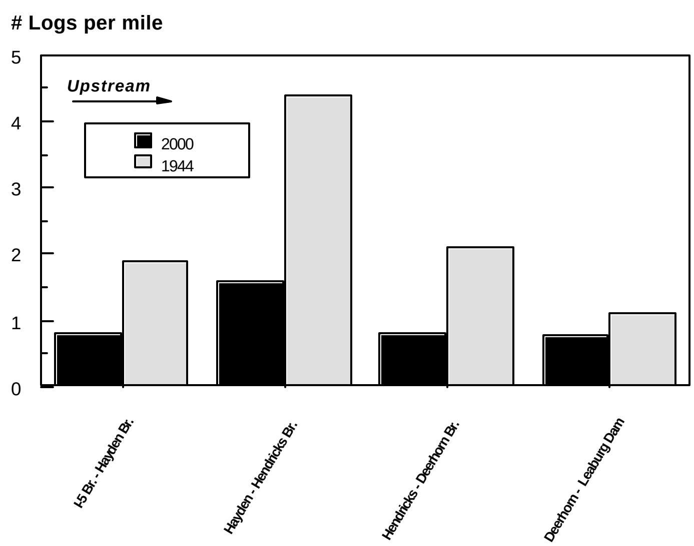


Figure 2-36. Single logs counted within the McKenzie River and on adjacent bars for 1944 and 2000 aerial photographs.

Log abundance in the McKenzie River was very low for both 1944 and 2000. We asked several residents who grew up along the river why wood was so scarce in the river in 1944. They pointed out that, while many logs came down the river during high flows, many small logging businesses and individuals regularly removed them from the river to sell at sawmills or to use as firewood. These residents pointed out that log salvaging from the river continues today, with most of the logs used for firewood. Also, a number of logs considered to be a safety hazard are cut into smaller pieces by boaters each year.

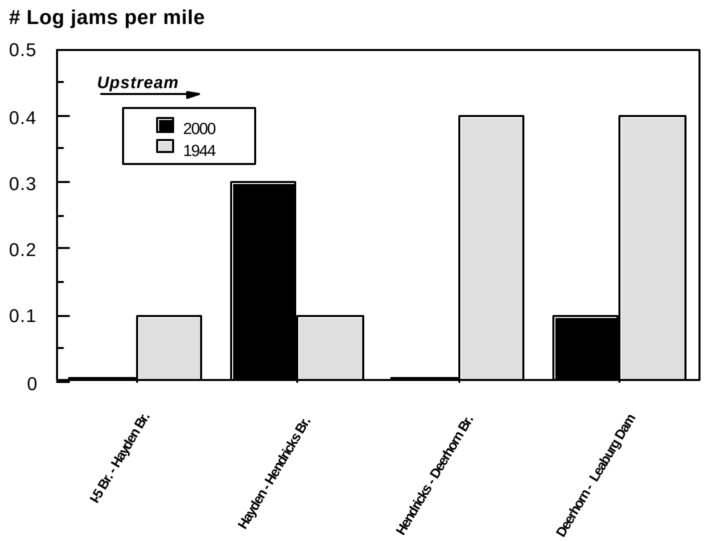


Figure 2-37. Log jams counted within the McKenzie River and on adjacent bars for 1944 and 2000 aerial photographs.

Log abundance in the McKenzie River is also influenced by the two large reservoirs. Logs catch behind the dams during high flows and are later removed by either the Corps of Engineers or, most recently, the Forest Service. Much of this wood is cut up for firewood or burned near the reservoir. However, in recent years the large conifer trees have been set aside by the Forest Service for use in stream habitat improvement projects. Without the dams, this large wood would have traveled downstream and contributed to the quality of fish habitat in the lower McKenzie River (or become firewood). Recently, some biologists have suggested that this wood be trucked downstream of the dams and placed back into the river to continue its course.

Overall, there is little hope that large wood abundance could ever be restored to levels even near that which existed prior to European settlement in the near future. The volume of wood would be very large and the ability to purchase logs of sufficient size would be limited. Even if attempted at a large scale, any logs placed in the river would probably be subject to the pressures that currently cause them to disappear.

Large wood was also probably ubiquitous in tributary streams prior to European settlement. Streamside trees that established following stand replacement fires often grew to an age of up to several hundred years. Streamside stands would usually produce substantial amounts of large wood after about 200 years due to mortality from competition, disease, or disturbance by the stream. A fire could occur anytime during the life of the stand, kill most trees, and thereby produce an accelerated supply of large wood as snags fell into stream over the next century. Large wood in tributary streams help create complex habitat (pools, low-velocity water, and sorted gravels) that salmonids need for habitat (Beechie and Sibley 1997, Andrus et al. 1988, Bilby and Ward 1991).

Wood abundance in tributary streams has generally decreased since European settlement due to wood removal and a reduction in the abundance and age of streamside trees to replenish wood in streams. Throughout the lower basin, many tributary streams were cleared of large wood to reduce the risk of localized flooding and meandering of channels across farm land. Some of the larger tributaries, such as the Mohawk River were cleared of wood to allow log drives and were further scoured when splash dams were used to make log drives more efficient. An effort by some fish biologists, who thought that wood was an obstacle to fish passage, to keep streams cleared of logging slash began in the 1950's (ending in the 1980's) and resulted in not only the removal of logging slash but also natural wood, including the large key pieces that create pools, sort gravel, and provide habitat diversity. In addition, some wood was removed from streams during timber harvest over the last century because of the value of these logs.

The following provides a summary of the current condition of large wood in a limited number of tributary streams downstream of the Quartz Creek Bridge and the potential supply of wood from the streamside forests currently growing along the streams:

> Mohawk River and its tributaries: Key pieces of large wood, those that are generally considered to be large enough to have a major influence on channel form, were very sparse throughout the basin (Huntington 2000). No key pieces were found in lowland reaches of tributaries. An average of <1% of the ODFW benchmark abundance of key pieces were present in lowland reaches of the main channel and an average of only 6% of benchmark values in the upland tributaries. Likely reasons for such low large wood abundance in channels include log drives, splash dams, intentional removal of wood, and a lack of large trees next to channels to provide a continued source of large wood.
>
> Lower McKenzie River tributaries – south side: None of the reaches that were investigated had large amounts of functional wood (Weyerhaeuser 1994). The greatest amount of functional wood was found in very small, steep reaches which had little stream power with which to remove or transport wood. Wood in these channels did little to increase pool frequency because of the coarse substrate, and steep gradient. Few of the reaches had active floodplains that supplied wood. If a floodplain existed, the stream was slightly to moderately incised into terrace deposits and hardwoods dominated the overstory. Most of the trees growing next to streams are less than 100 years old and are not yet yielding much of a supply of key pieces of large persistent wood.

Quartz Creek and nearby tributaries: Quartz Creek had low levels of large wood in the channel, except where large logs were intentionally placed in the stream as part of restoration project (Mattson et al. 1998). Most trees near the stream had been harvested about 20 years ago and so wood levels are likely to remain low for many decades. Four out of five smaller tributaries near Quartz Creek also had low levels of wood. In addition, all of the tributaries had low numbers of older conifers growing next to the channel. Older conifer stands are the best suited for adding significant inputs of persistent wood during the next century.

Overall, the prospect of large wood existing in McKenzie River tributaries at levels similar to that which existed prior to European settlement is not hopeful. Current stands of riparian trees are young and often conifers are absent.

Aquatic insects

Aquatic insects are a main food source for most fish in the McKenzie River. The abundance and community structure of aquatic insects can vary widely in a basin depending on nutrients in the water, water temperature, amount of light hitting the water, water depth, substrate size, and bedload movement. Increasing nitrogen and phosphorus in a river can promote algae growth and the group of insects that graze on attached algae. An increase in grazing insects can then boost those insects that feed upon grazing insects.

Higher water temperature and greater exposure to sunlight also can promote algal growth and lead to a shift of more grazing insects. Deep water blocks out much of the sunlight needed for photosynthesis and development of a food base for aquatic insects, while shallow water results in higher primary productivity. A coarse substrate of cobbles will support a different community of aquatic insects than a substrate of finer material. Cobbles are less likely than small gravel to tumble during higher flows, thereby creating a more stable bed that is favorable to long-lived species. Also, a coarse substrate offers more hiding places for those insects that have no other way to avoid predators.

The McKenzie Watershed Council sampled aquatic insects for selected tributaries of the upper and lower McKenzie River in 1998 and 1999 (Aquatic Biology Associates 2000). Benthic organisms were identified to the lowest possible taxa and enumerated for each sample. The resulting output usually includes dozens of genera which makes comparisons between streams difficult. To simplify matters we report only the percent of organisms that consisted of mayflies, stoneflies, and caddisflies. As a group, these three types of insects are often referred to EPT (a acronym based on their scientific names). EPT are favored food items for many fish and their numbers are sensitive to changes in their environment.

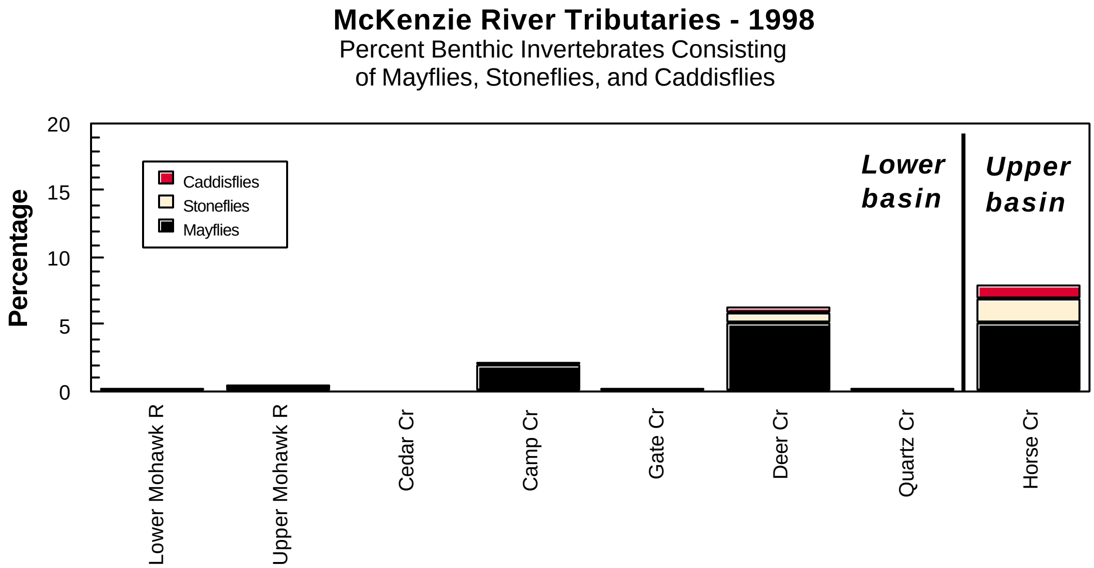
Horse Creek, a tributary flowing mostly through a wilderness basin had the highest percent EPT values (8%) of the eight tributaries sampled in 1998 (Figure 2-38). Percentages were similar for Deer Creek (downstream of Quartz Creek) which has one fork of the watershed bordered by a logging road. Elsewhere, EPT were at very low levels or, in the case of Cedar Creek, absent.

In 1999, 14 streams were sampled with 5 located in the lower basin. On average, lower basin tributaries had lower EPT values than did tributaries in the upper basin (Figure 2-38). The highest value was 17% in Pothole Creek. An additional stream not shown in Figure 2-39 has an EPT value of 35%. It was located high in the basin and was spring-fed. Because of relatively constant flows and abundant phosphorus from the new volcanic rocks along the crest of the Cascade Mountains these insects thrived. EPT rates for the Mohawk River were zero or nearly zero for both years of sampling. The lower Mohawk River gets quite warm in the summer and has a sandy substrate.

Aquatic insects were sampled in 1988 for a transect of the lower McKenzie River (Figure 2-39). It was conducted in such a way that comparisons of aquatic insect communities within and downstream of sections that are partially dewatered by the power canals could be made (EA Engineering, Science, and Technology 1990). The percent of aquatic insects comprised of EPT taxa did not vary significantly among sites in the Leaburg bypass, Walterville bypass, and reaches that had no water diversion. Data from this study indicated good abundance and diversity for the three key insect families.

The percent EPT values were high (55% to 95%) when compared to samples from tributary streams and samples that were gathered from the Willamette River near Eugene (data gathered by the City of Eugene, Public Works). Also, a single sample from the lower McKenzie River gathered in the fall, 1999 (downstream of the Hwy I-5 Bridge) had an EPT value of only 3.6%. The high EPT values in the 1988 study may have been due to a difference in sampling methods. It is likely that the 1988 methods resulted in an undercount of the smallest-sized insects, thereby making the larger-sized EPT percentages relatively high.

Further sampling of the main channel using methods common to the other studies (developed by the Oregon Department of Environmental Quality) is needed to better understand aquatic insects in the main channel and allow comparisons with samples taken from tributaries. Additional investigation also would be warranted to better understand why lower McKenzie River tributaries lack insects that are most favorable to salmonids.



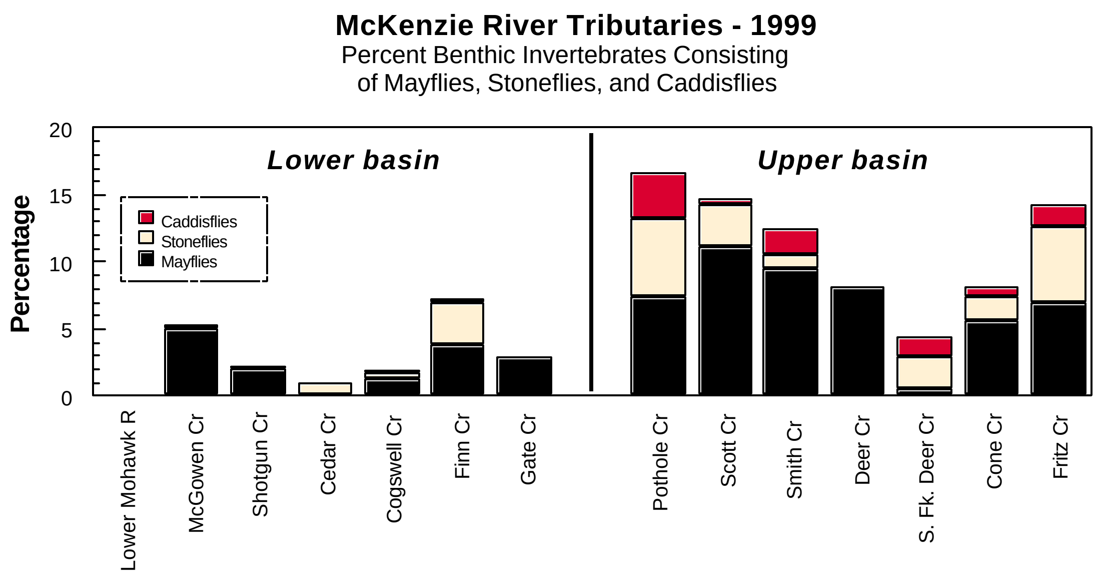


Figure 2-38. Percent benthic invertebrates consisting of mayflies, stoneflies, and caddisflies for tributary streams of the McKenzie River in 1998 and 1999. The lower basin is downstream of the Quartz Creek Bridge and the upper basin is upstream.

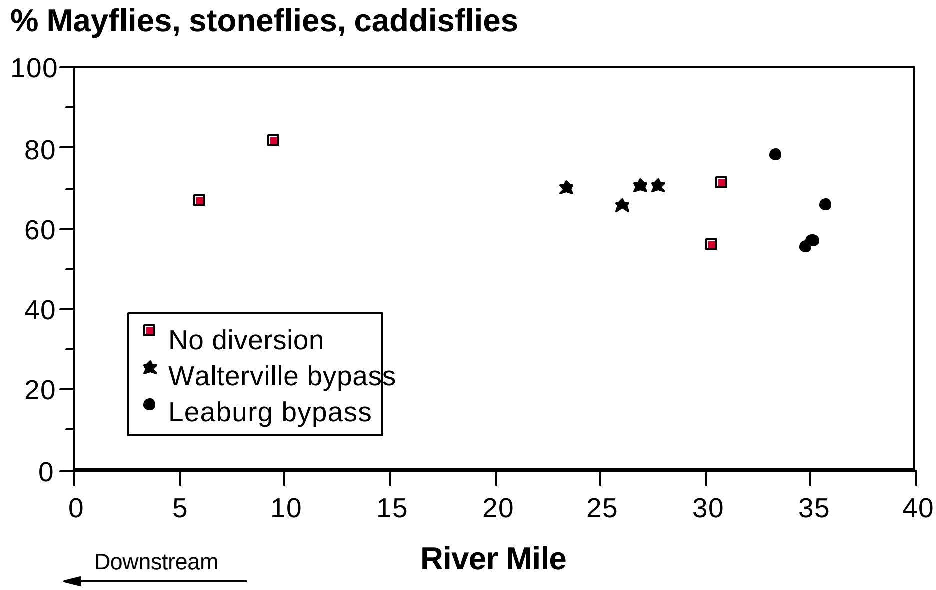


Figure 2-39. Percent benthic invertebrates consisting of mayflies, stoneflies, and caddisflies for main channel sites between Leaburg Dam and the McKenzie River confluence (EA Engineering, Science, and Technology 1990). Included are sites for which part of the flow was diverted to power canals and sites without diversion.

Future Trends for the Aquatic Ecosystem in the Study Area

The social and physical landscape of the McKenzie River basin is continuing to change as human growth occurs, use of the land changes, and public and private entities respond to recent mandates to restore fish and wildlife in the McKenzie River watershed. So far in this document, we have described changes in watershed function and condition from European settlement to the present. We now attempt the more difficult task of estimating probable changes in watershed functions and habitat during the next few decades.

Under current zoning and policies, human population growth in the watershed will probably not be a primary driver of change in most portions of the McKenzie River simply because there are few opportunities to build. Recent analysis by Lane County indicates that of 3121 parcels within developed and committed exception areas of the watershed (excluding Springfield) only 18% are vacant under current zoning restrictions (Table 2-6). Future demand for infrastructure (e.g. sewage treatment and potable water) is not likely to be high with such a low vacancy rate.

Undoubtedly, a number of existing homes have old, failing septic systems and so there will be a need upgrade existing dwellings. Opportunities to adequately treat sewage on-site will be challenging for many riverfront sites due to thin soils, small lot size, high water table, and porous soils. Overall, there will probably be an increase in bacterial contamination in the shallow water table and river as septic systems age and come to the end of their useful life (20-30 years). It appears that a majority of houses in the watershed have been built within the last 30 years.

Table 2-6. McKenzie watershed build-out potential for developed and committed exception areas under current zoning (2000 data from Lane County). * estimated.

	# Acres	Total Parcels	Vacant Parcels	% Parcels Vacant
Hwy I-5 Bridge to Mohawk River	185	40	11	28
Mohawk River Basin	4683	1143	179	16
Mohawk River to Walterville	2226	675	108*	16
Walterville to Leaburg	1511	573	71	12
Leaburg to Vida	501	163	28	17
Vida to Nimrod	958	245	68	28
Nimrod to east of McKenzie Bridge	603	282	116	41
Overall	10667	3121	557	18

Development along the eastern and northern edges of Springfield may be where population growth occurs the most in the next few decades. Here, stormwater disposal, sewage treatment, and encroachment upon flood plains will be important issues.

Uses of the land will likely continue to evolve during the next decades and probably reflect changes already underway. Owning farm and non-industrial forest land primarily for agricultural production and timber harvest will probably continue to decline as people increasingly view the basin as a place to have a house or acreage for scenic values or as places of solitude. We expect that working farms will continue to give way to part-time farms and hobby farms.

The process of converting unmanaged second-growth stands to managed plantations has been nearly completed for most industrial forest land in the basin and this will probably be followed by a period that tends towards short rotations (40-60 years) and intensive management (brush control, regeneration, thinning, and fertilization). Private forest land is now nearly fully roaded and so sediment production due to new road construction will be minimal. Older trees will be found mainly along streams and other limited leave areas. In contrast, forest lands on public land will probably experience relatively little activity over the next decades. New mandates on resource protection and recovery will likely result in only limited timber harvest and road building. Federal activities will include restoring degraded fish and wildlife habitat.

Recreation will probably become an ever-increasing use of the river, and with it, conflicts among the various users of the river. A recent surge in the number of whitewater outfitters using the McKenzie River has highlighted the nature of these conflicts, including the unauthorized use of residential yards by boaters, litter, noise, and crowded conditions. House construction on now-vacant riverfront lots and disturbance of riverfront vegetation (one-third are still vacant) and the re-development of occupied parcels will also probably be part of the conflict.

Gravel extraction will continue to cause changes to land immediately adjacent to McKenzie River downstream of the Highway I-5 Bridge and perhaps between Hayden and Hendricks bridges, another area with high-quality gravel deposits. Future gravel operations will probably be less intrusive than existing gravel operations because of state and federal environmental mandates for set-backs on pits and greater restrictions on channelizing the river. There will probably be more efforts made to reclaim gravel pit ponds and make them useful areas for fish and wildlife. Currently, four gravel aggregate operators, in cooperation with the McKenzie Watershed Council, state and federal agencies, the McKenzie River Land Trust, farmers, and other entities are exploring voluntary opportunities for improving fish and wildlife habitat near the confluence of the McKenzie and Willamette rivers.

The river's dams and hydroelectric facilities will probably continue to operate much as they have in the recent past with the following exceptions. First, construction is underway to provide Cougar Dam with a variable-depth water outlet control that will allow the Army Corps of Engineers to keep the South Fork of the McKenzie River near its natural temperature. This should help improve spring chinook salmon spawning and rearing. Second, a screen will be installed next year at the inlet to the Walterville canal thereby, keeping fish out of the power turbines.

Peak flow dampening will likely continue at Cougar and Blue River reservoirs to protect downstream houses and other infrastructure built within the pre-reservoir flood plain during the last 50 years. There will probably be a demand for the Corps of Engineers to further dampen peak flows as riverfront development occurs on the remaining one-third of vacant parcels. Many of these vacant parcels are more flood-prone than those that have already been developed. Privately-funded riprap will likely accompany housing development at these floodprone parcels. It is unclear whether of not the Corps would respond to pressures for greater flood control since the ecological aspects of their activities have come under greater scrutiny. Nevertheless, serious property damage will infrequently occur during the very largest of flood events (e.g. 1946 and 1964); flows of this magnitude exceed the capability of the two flood control reservoirs in the McKenzie basin.

Fish habitat in the main channel will likely experience only modest decreases in quality over the next few decades. The major alterations to habitat (large wood removal, peak flow dampening, and channelization) have already occurred. Future riverfront development on remaining riverfront parcels, the trend towards greater tree removal at house sites, increased demand for safe boating recreation, continued interception of large wood at reservoirs, and wood salvaging from the river will probably prevent any significant recovery of large wood loads in the lower McKenzie River.

Large wood loads will probably increase over time in tributaries that flow across forest land as streamside leave-tree requirements result in older streamside trees that are inherently more capable than young trees to bolster wood levels in streams. Large wood loads in tributaries will probably recover at a faster pace on public forest land due to the greater numbers and size of trees retained in streamside leave areas. Projects aimed to bolster large wood abundance in channels will probably continue on both private and public forest land but the scale of effort will likely not be sufficient to address more than a minority of stream miles under current funding levels.

Detailed Recommendations for Conservation and Restoration of the Aquatic Ecosystem

One approach to habitat conservation and restoration is to assume that the best habitat for an organism is the habitat it evolved with. The 1944 aerial photographs help us understand how habitat features have changed during the last 56 years and where the best habitat existed, but in 1944 the river was already changed in many ways. The channel had been cleared of logs and other obstacles to make log drives more efficient; farm land and pasture already extended into riparian areas; and large, old trees had already been harvested. So we have only an already altered picture of the original habitat in the McKenzie River.

An alternative approach to habitat conservation and restoration is to protect the best remaining habitat, determine which types of habitats are in short supply, determine where those limited habitats do exist, and create these important habitat features elsewhere in the river. We have adopted a blend of these two approaches, concentrating on where natural processes once created the best habitat (no matter what condition the habitat is in today), while also focusing on where much of the good habitat remains today.

The following recommendations for conservation and restoration of the aquatic ecosystem are based on this blended approach.

- Focus river habitat <u>conservation</u> efforts first on: a) reaches between Hendricks Bridge and the I-5 Bridge; and b) reaches in the Willamette River downstream from the current confluence where side channel and island habitat are most abundant. In these reaches, the river is unconstrained, the channel meanders widely, and habitat is still complex.

- Focus <u>restoration</u> efforts first on: the reaches downstream from the I-5 Bridge where high quality habitat was once abundant.

- Force channel complexity back into the lower river through restoration actions (spread the river out). Because the dams have reduced peak flows, deliberate action will have to be taken to carry out once-natural processes such as channel meandering and the creation of off-channel features. Excavated or constructed habitat features should be aligned with the main channel so that little sediment is deposited in the new features.

- Encourage the US Army Corps of Engineers to seek funding to modify Blue River Dam, in order to repair the problem of warm water releases in late summer and fall from Blue River Reservoir.

- Continue to identify warm tributary streams and determine which segments of those streams lack shade or have excessive water withdrawals. Focus first on valley-floor stream segments that do not flow through federal or private forest land. Determine the causes of warming for streams already identified as abnormally warm.

- Search out landslide-prone segments of road and repair them before landslides occur.

- Educate landowners and developers about the risks of building homes in historic landslide torrent tracks and in flood-prone areas next to the river (especially between Hendricks Bridge and Hayden Bridge).

- Encourage Springfield to locate sources of fecal contamination coming from stormwater pipes.

- Put special emphasis on protecting areas that currently have high channel complexity (McKenzie River between Hendricks Bridge and Hayden Bridge, Willamette River between the present-day and old McKenzie confluences). Expand channel complexity by opening up plugged side channels and connecting certain ponds to the river.

- Encourage the Oregon Division of State Lands and Lane County to work cooperatively to ensure that landowners who are riprapping banks at riverfront homes have the necessary permits. Work with county commissioners to minimize bank riprapping when approving plans for new riverfront house construction. Look for opportunities to assist willing landowners to move the top tier of riprap back from the river and plant the resulting low terrace with trees.

- Seek conservation of scarce, older tree stands along the river. Focus conservation and restoration in reaches with abundant gravel bars and willow (indicators of a meander area). Focus vegetation restoration activities on land nearest the river that is currently farmland, grass, and brush. Consider planting Douglas-fir in well-drained locations along the lower McKenzie River, since Douglas-fir once grew there.

- Encourage Springfield and Lane County to manage riverside development to comply with revised city and county regulations for riparian areas. Encourage county commissioners to adopt the revised riparian corridor rules and to plan for the enforcement of these rules.

- Investigate why many favored aquatic insects are missing from lower basin streams. Initiate a study of aquatic insects in the main channel (using Oregon Department of Environmental Quality methods), in order to understand insect abundance and community structure.

Fish species of the McKenzie River

Eight families of fishes, with 23 species, are native to the McKenzie River Basin. Non-natives bring the total to 11 families and 31 species (Table 2-7). Of all the species in the basin, the focus of most studies has been on those in the salmon and trout family (Salmonidae). The following sections will describe life history, range, and population trends of the native chinook salmon, rainbow trout, cutthroat trout, bull trout, and mountain whitefish, and the non-native summer steelhead.

Chinook Salmon (*Oncorhynchus tshawytsha*)

The chinook salmon is found throughout most of the Pacific drainages of North America. There are more than one thousand spawning populations of chinook on this continent (Groot and Margolis 1991). Although chinook are the least abundant salmon species in the Pacific coast states, they support important commercial and sport fisheries.

Chinook salmon populations worldwide are highly variable in terms of age at seaward migration, length of freshwater and ocean residence, ocean distribution and migratory patterns, and age and season of spawning migration. The convention of dividing the species into "stream" and "ocean" types is useful in distinguishing spring, summer, fall, and winter runs of chinook. Stream-type chinook exhibit longer freshwater residence as juveniles, return from the ocean in the spring and summer, and spawn in late summer or early fall. Ocean-type chinook spend only a few months in freshwater as juveniles. Adults migrate upstream in the late summer or fall, and spend very little time in freshwater before spawning. Generally, stream-type are called spring chinook, and ocean-type are called fall chinook. Wherever they occur in the same drainage, stream-type chinook tend to occupy the headwater spawning areas, whereas the ocean-type fish tend to be found in mainstem river spawning areas.

Some fall chinook may still exist in the lower Willamette River from discontinued hatchery programs, but only spring chinook are still found within the McKenzie River subbasin. Therefore, the following discussion will focus on spring chinook.

Life history

Adult spring chinook salmon migrate up the Columbia River in March and April, and reach the McKenzie in May. They hold in deep pools and runs over the summer, and move upstream to spawning areas in August and September. Spring chinook spawn in areas with large gravel or cobble substrate, with current velocities of about 1 to 3 ft/sec. Intra-gravel flow may be a key criterion in choosing the redd site. Redds are large, averaging about 170 ft^2 in area. Females deposit 2000 to 17000 eggs, correlated with body size. Adults die after spawning.

Table 2-7: Fish species occurring in the McKenzie River (compiled by Carl E. Bond and ODFW). * = introduced species

<u>Lamprey family</u>
- Western brook lamprey
- Pacific Lamprey

<u>Sturgeon family</u>
- White Sturgeon

<u>Salmon, trout, and whitefish family</u>
- Chinook salmon
- *Summer steelhead trout
- Mountain whitefish
- Resident rainbow trout
- Cutthroat trout
- *Brown trout
- Bull trout
- *Brook trout

<u>Minnow family</u>
- Redside shiner
- Chiselmouth
- Peamouth
- Northern pikeminnow
- Longnose dace
- Speckled dace
- Leopard dace
- *Common carp

<u>Sucker family</u>
- Largescale sucker
- Mountain sucker

<u>*Catfish family</u>
- *Brown bullhead
- *Yellow bullhead

<u>Trout-perch family</u>
- Sand roller

<u>*Livebearer family</u>
- *Mosquitofish

<u>Stickleback family</u>
- Three-spine stickleback

<u>*Sunfish family</u>
- *Bluegill
- *Largemouth bass

<u>Sculpin family</u>
- Paiute sculpin
- Shorthead sculpin
- Reticulate sculpin
- Torrent sculpin

The eggs remain in the substrate over the winter, and fry emerge in late winter or early spring. On average, less than 30% of the eggs deposited produce fry. Chinook fry rear in the stream margins, in shallow, low-velocity water. When they reach a size of about 2 to 3 inches, they begin to move into deeper water with low to moderate velocity; at this point they are considered juveniles.

Juvenile spring chinook salmon remain in the river through the next year before beginning their trip to the ocean. Young chinook feed on small invertebrates: mainly aquatic larvae and terrestrial insects. Out-migration occurs over several months, beginning as early as the fall (Figure 2-40). Spring chinook usually spend 3 to 4 years in the ocean before returning to their native rivers to spawn. Hatchery fish may return from the ocean sooner than wild chinook.

Distribution in the McKenzie River Subbasin

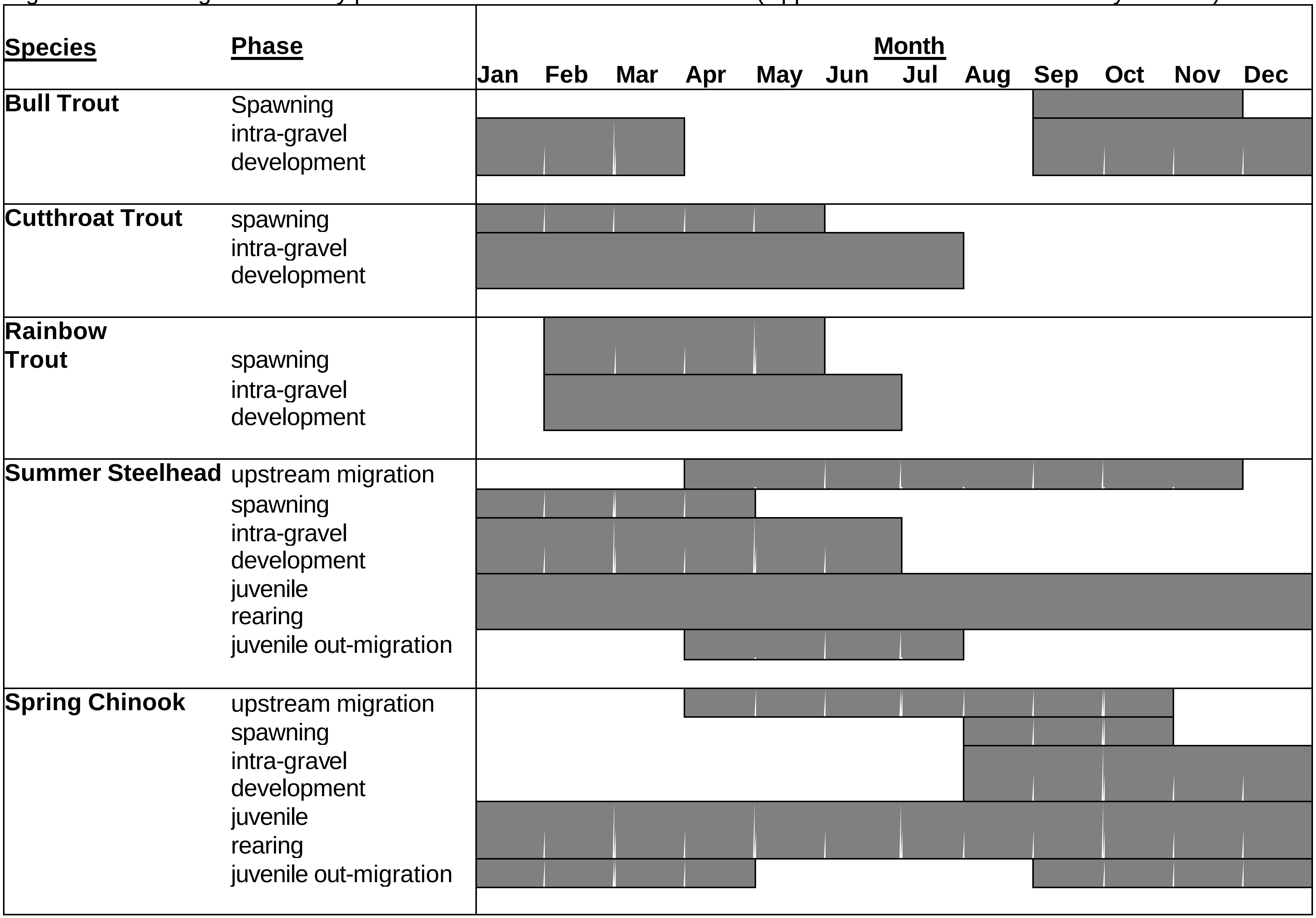
Spring chinook are distributed in the mainstem McKenzie River from the mouth to Trail Bridge Dam. They also use the South Fork to Cougar Dam, the Blue River to Blue River Dam, and the Smith River to Smith Dam. Many tributaries are used by spring chinook, including Horse Creek, Lost Creek, Deer Creek, Gate Creek, and the Mohawk River. The major spawning areas within the basin include the mainstem McKenzie, Horse Creek, Lost Creek, 4.5 miles of the mainstem South Fork McKenzie (below Cougar Reservoir), and Gate Creek.

Status

Prior to European settlement in the area, an estimated 8 million anadromous salmon and steelhead trout spawned each year in the Columbia Basin (Chapman 1986). Hatchery introductions began slowly in 1902 with significant returns beginning in the 1950s. Hatchery efforts were relatively unsuccessful before then because only fry and fingerlings were released, and these were often in poor condition due to imperfect hatchery conditions. In recent years, only around 2.5 million fish have returned, and of these, 90% are hatchery supported. Spring and summer runs of chinook are extinct in many parts of their historic four-state range of Washington, Oregon, Idaho, and California; only three healthy native stocks remain in the area (Huntington et al. 1996).

Willamette spring chinook are considered part of the Lower Columbia spring chinook group (below Bonneville Dam). Only 5-15% of the total lower Columbia/Willamette spring chinook are estimated to be non-hatchery production. Historically, the McKenzie was thought to provide the best spring chinook spawning grounds above Willamette Falls, with 40-50% of the total run. In recent years, the majority of fish passing the Leaburg Dam are considered to be wild (Figure 2-41). Today the McKenzie River provides the one of the best spring chinook spawning areas within the lower Columbia river system, and the healthiest run of spring chinook in the Willamette basin (Howell et al. 1985; ODFW 1999). Even so, the McKenzie run is not considered a healthy stock by the criteria of Huntington et al. (1996). Even so, the McKenzie run is not considered a healthy stock by the criteria of Huntington et al. (1996).

Figure 2-40. Timing of life history phases of Lower McKenzie salmonids (Upper McKenzie Watershed Analysis 1995).



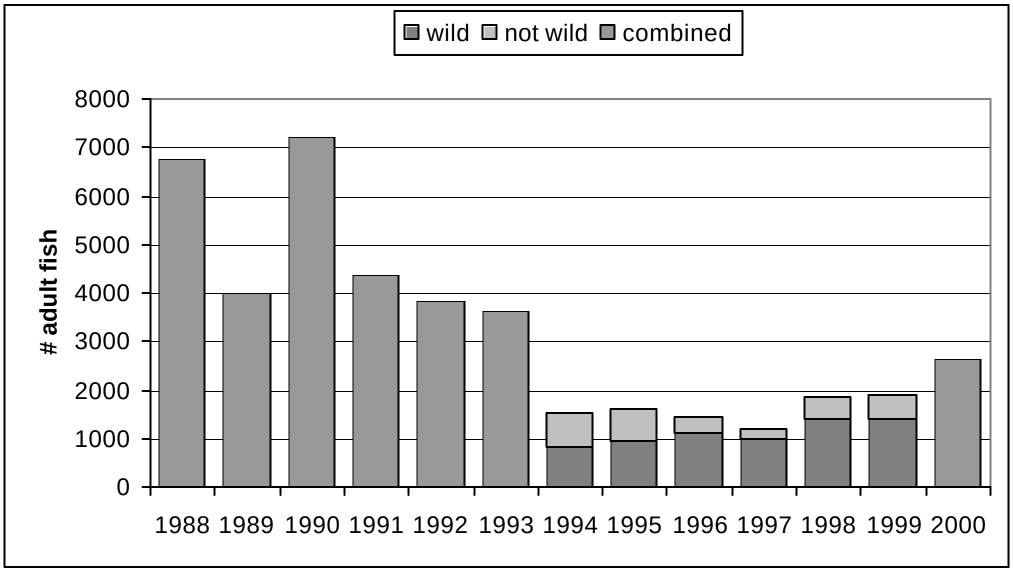


Figure 2-41. Spring chinook observed at Leaburg Dam, 1998-2000.

Dams at Blue River, Cougar and Trail Bridge block access to a significant amount of historic habitat. Additionally, warm top-water releases from reservoirs in the fall hasten egg development downstream, which results in the emergence of fry earlier (and under harsher conditions) than under historic natural conditions (Cougar Dam is currently being retrofitted to release cooler water). Other factors that have contributed to the decline of the spring chinook population in the McKenzie River subbasin include road-building and timber harvest practices, unscreened diversion canals, mainstem channel de-watering below the EWEB diversions (although minimum flows have increased significantly in recent years), and competition and hybridization with hatchery salmon. Despite the continuing problems of habitat degradation, hatcheries, and dams, high quality spawning and rearing habitat still exists.

Conditions in the Willamette River also influence the McKenzie River spring chinook runs. Potential adverse effects include the loss of riparian habitat (marshes, riparian forest), channelization, gravel quarrying, habitat degradation associated with urban and industrial development, and agricultural and timber harvest practices.

In recognition of its historical importance as habitat for bull trout and wild spring chinook salmon, much of the McKenzie River subbasin has been designated a Tier 1 Key watershed by the U.S. Forest Service under the Northwest Forest Plan. Spring chinook salmon are an ODFW Stock of Concern -- Category 1, and are listed as Threatened under the federal Endangered Species Act.

Annual aerial redd surveys of the entire river above McKenzie Bridge and in the Carmen spawning channel show that redds have increased at a greater rate in the upper vs. the lower watershed since the mid-1980s (Upper McKenzie W.A. 1995). However, overall redd counts have declined significantly over the past decade.

The numbers of redds found below Leaburg Dam have declined in the past 2-3 decades (Figure 2-42). Part of the drop since the 1970's is due to the fact that non-native fall chinook redds were included in the counts; when the stocking of fall chinook stopped, total redd count declined (Cramer et al 1985). Even so, counts in recent years are far lower than the habitat could support.

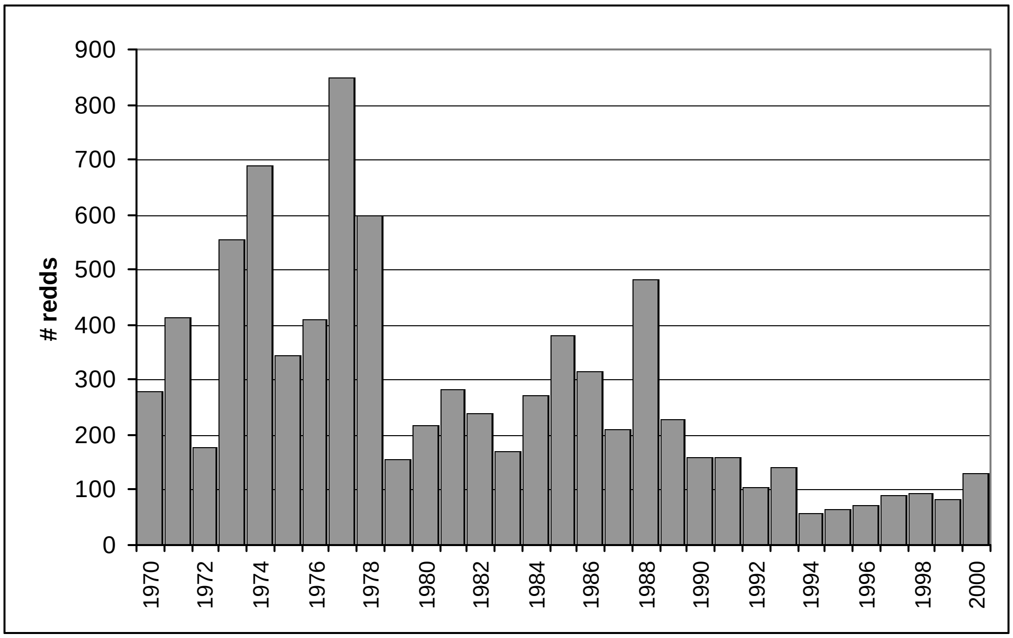


Figure 2-42. Spring chinook redds observed in the McKenzie below Leaburg Dam.

Impact of Hatcheries

The introduction of hatchery fish to a system can be detrimental to wild populations for at least two reasons. First, hatchery smolts compete directly for food and space with wild juveniles. When hatchery fish are released, wild fish must expend energy competing for space and food with the hatchery fish, or else move out of the area. Second, hatchery fish have lower overall fitness in the environment, such as lower spawning success and lower survival from egg to adult. When hatchery fish interbreed with wild fish, the offspring have lower fitness compared to purely wild offspring. (American Fisheries Society 2000).

Hatchery-produced chinook salmon have been used extensively in the McKenzie River in an effort to bolster natural production, and to provide for a continuing sport fishery. In recent years, over 1,000,000 hatchery smolts have been released annually into the McKenzie (Figure 2-43), and this trend is projected to continue, at least in the near future (M. Wade, ODFW, pers. comm.). Additionally, hatchery chinook pass upstream of Leaburg Dam, and probably inter-breed with wild chinook upstream. Adult hatchery chinook are also released in Cougar Reservoir (Figure 2-44); presumably, these fish are spawning in tributaries, and producing unmarked hatchery-derived young. ODFW occasionally releases chinook fry in Cougar Reservoir as well, some of which could conceivably pass through turbines to intermingle with wild fish below the dam. The precise effect of these practices on the wild chinook is unknown, and may be detrimental (American Fisheries Society 2000).

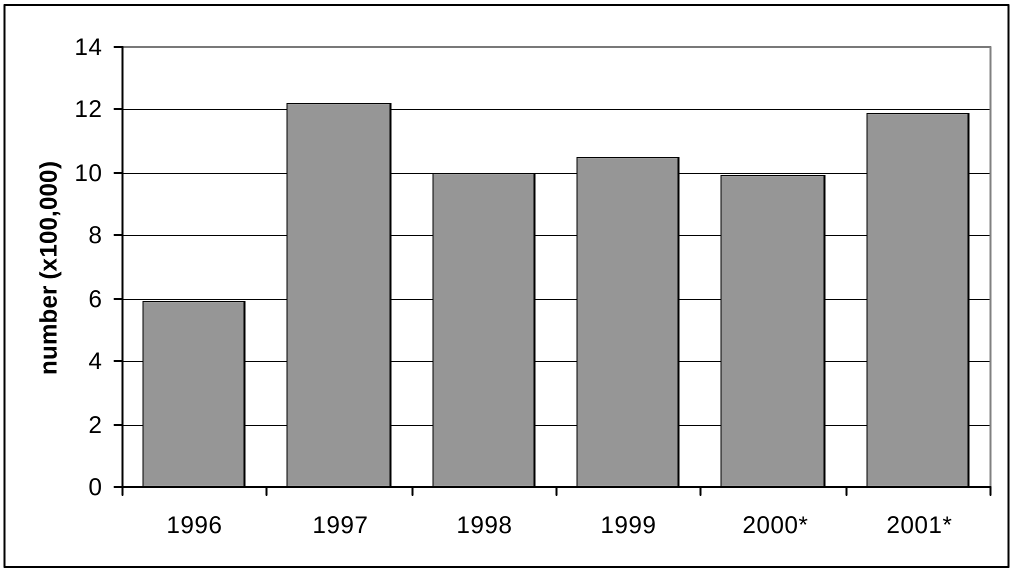


Figure 2-43. Leaburg Hatchery spring chinook smolts released, 1996-1999; predicted release, 2000-2001.

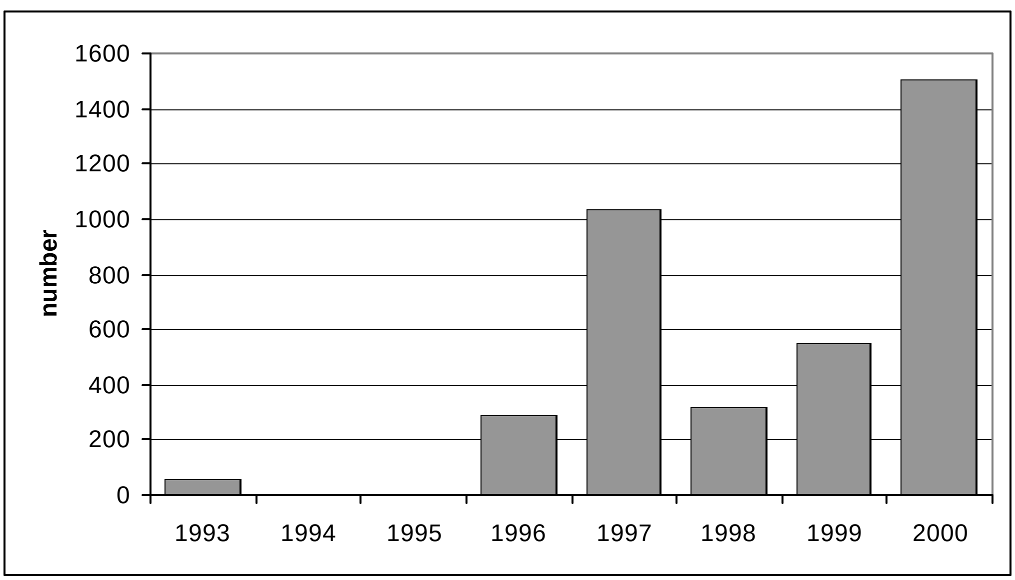


Figure 2-44. Adult hatchery chinook released above Cougar Reservoir, 1993-2000.

Spring chinook salmon habitat limitations and restoration opportunities

Spawning habitat for chinook salmon does not appear to be in short supply in the McKenzie. A habitat survey (Hardin-Davis 1987) found abundant potential spawning gravel between Leaburg Dam and Walterville tailrace; much higher redd counts in some years are also an indication that spawning habitat is not limiting. If chinook populations are limited by habitat, then it is almost certainly rearing habitat for fry and juveniles.

Fry and juvenile chinook use a variety of habitat types over the 1-2 years they spend in freshwater. Fry in the McKenzie are generally found along the river margin, where fish can find food and find shelter from velocity, and escape predation (J. Ziller, pers. comm.). Similar observations have been made in the Klamath River, where fry are almost always closely associated with cover in the form of submerged vegetation or boulders (Hardin-Davis et al., in progress). Fry are often at the edge of a "shear zone", that is, they hold in low-velocity water near swifter water that transports food items.

In free-flowing portions between Leaburg Dam and to Hayden Bridge, side channels were one of the three most-used habitat types for larger juveniles (Hardin-Davis et al. 1990). For smaller juveniles and fry, side channels are probably even more important , due to reduced velocities and the high amount of edge habitat.

Another indication that habitat diversity is important for juveniles is found in measurements of velocity immediately adjacent to the fish location (focal point). Measurements taken on 120 fish between Leaburg Dam and Hayden Bridge showed that 72% of the time, adjacent velocity exceeded focal velocity by at least 0.5 ft/sec. The difference was over 1.0 ft/sec for 45% of the observations (Hardin-Davis et al. 1990).

Comparison of habitat conditions between 1944 and present indicates that side channel and island area has decreased, particularly in Reaches 3-5 and 10-15 (Figures 2-19 and 2-23). This probably represents a substantial loss of rearing habitat for chinook salmon. At the same time, the number of houses below Leaburg Dam has increased about 4-fold; this has led to loss of riparian vegetation and other types of cover along the banks, which are crucial for fry.

While it is difficult to pin down a single cause for declining numbers of a fish species, it is apparent that chinook salmon need channel diversity. A more natural channel pattern that allows formation of side channels and islands would improve rearing habitat. Increased cover along the margins for fry would also be likely to benefit the chinook population.

Rainbow Trout *(Oncorhynchus mykiss)*

The native rainbow trout in the McKenzie River is formally known as the Columbia River redband rainbow trout (Behnke 1992). It is a resident fish, which distinguishes it from its genetic near-twin, the sea-run steelhead, which has been introduced and is still stocked in the McKenzie.

Life history

Rainbow trout spawn in the mainstem McKenzie River and in the larger tributaries in the spring. The range of spawning times may be from late February through early June. Hardin-Davis et al. (1990) found large numbers of spawning rainbow trout in late April between Leaburg Dam and Hayden Bridge.

The female rainbows dig redds in areas of moderate velocity with medium to small gravel. The fry emerge from the substrate in late spring or early summer. Residence time in the gravel can vary from 30 to 60 days or more, depending on the temperature.

Fry rear in the stream margins, then gradually move into faster water as they grow into the juvenile life stage in late summer or fall. Juvenile and adult rainbow trout occupy all portions of the mainstem McKenzie River. Their preferred locations appear to be near the boundaries between fast and slow-water habitats, where holding areas are close to currents that carry drifting aquatic insects. These areas include the heads of pools, boulder cover within riffle areas, and side channels.

Distribution in the McKenzie River Subbasin

Resident rainbow trout in the McKenzie Basin occur in the mainstem from the mouth upstream to Tamolitch Falls and in the lower portions of medium and large tributaries above Leaburg Dam (ODFW 1999). Rainbow trout are the most abundant game fish in the mainstem, with the possible exception of mountain whitefish (Howell et al 1988). They are absent from headwaters, small tributaries, and most areas above historical barriers.

Status

ODFW (1999) lists 5 separate wild populations of resident rainbow trout in the McKenzie Basin, all above Quartz Creek:

1. McKenzie River below Trail Bridge and Cougar dams
2. Blue River above Blue River Dam
3. McKenzie River above Trail Bridge Dam
4. South Fork McKenzie River, Cougar Reservoir to river mile (RM) 28.5
5. South Fork McKenzie River above RM 28.5

The native stocks face competition from at least two non-native populations of the same species: stocked, non-native resident rainbow trout, and introduced summer steelhead.

Hatchery rainbow trout have been stocked in the McKenzie River since the early 1900's. Stocking of hatchery fingerlings (juveniles) was discontinued in the 1950's, and was replaced by stocking of legal-sized rainbows in 1947. Currently, up to 125,000 hatchery rainbow trout are stocked every year. Present-day stocking locations include the mainstem, from Bellinger Landing (RM 19) to Forest Glen Landing (RM 53.5), Leaburg Lake, and Blue River above Blue River Reservoir. In the recent past, hatchery rainbow trout have been stocked at many other locations both upstream and downstream in the basin (ODFW 1999).

Sea-run steelhead and resident rainbow trout are taxonomically the same species, but steelhead are not native to the McKenzie River. Summer steelhead smolts have been released each year since 1972 from Leaburg Hatchery. Numbers of smolts released have averaged about 115,000 per year since 1990. The catch of adult steelhead during this same period has averaged about 1500 per year. Steelhead spawning has been observed in the mainstem, but is believed to produce few returning fish. Most (ODFW estimates 95%) of the fish returning to the McKenzie River are hatchery-produced.

The effects of hatchery rainbow trout and summer steelhead populations on the wild McKenzie river rainbow trout have not been quantified. Some interbreeding probably occurs, but the extent is unknown. Competition for food and space can occur during two life stages: at the juvenile stage, hatchery steelhead smolts compete with wild resident juveniles. At the adult stage, hatchery rainbows compete with native adults. Angler catches give some clues as to the impacts of hatchery fish. The proportion of wild rainbow in angler catches was 46% in 1950, but only 11% in 1983. This difference may reflect a decline in wild stocks, but it may also reflect the greater ease with which hatchery fish can be caught.

Rainbow trout habitat limitations and restoration opportunities

Spawning habitat does not appear to be the limiting factor for resident rainbow trout in the McKenzie. Rearing habitat for juvenile and adult fish may be in shorter supply (ODFW 1996). In a study of habitat use by rainbow trout from Leaburg Dam to Hayden Bridge, Hardin Davis et al. (1990) found that side channels were preferred to all other habitat types in the river by juveniles and adults. As with juvenile chinook, adjacent "shear" velocities were important; however, the effect was more pronounced. For adult trout, the median observed adjacent velocity was 2.5 ft/sec, vs. 1.2 ft/sec for focal velocity. For juvenile trout, the respective numbers were 1.8 vs. 0.7.

Side channels and shear zones appear to be even more important for rainbows than for chinook. Thus the recommendations for increased channel diversity made above would apply to rainbow trout populations as well.

Cutthroat Trout *(Oncorhynchus clarki)*

Cutthroat trout are closely related to rainbow trout. The subspecies occurring in the McKenzie Basin is the coastal cutthroat trout; these are native to the entire McKenzie River basin. They are more widespread than rainbow trout, as they inhabit many high-gradient tributaries that rainbow trout avoid. ODFW lists 40 different populations of cutthroat trout in the basin. The large number of distinct populations is due to the isolation of many of the populations above barriers.

Life history

The general life history pattern of the cutthroat is similar to that of the rainbow. Spawning occurs in the spring, often beginning slightly earlier than rainbow spawning. Spawning behavior, residence time in the gravel, and fry development are similar to rainbow trout. Despite these similarities, the species maintain their genetic identities by geographic separation. Many cutthroat trout tend to occupy smaller tributaries and headwater areas. Where the two species co-occur in the mainstem, cutthroat are more likely than rainbow to ascend tributaries to spawn.

The cutthroat trout in the mainstem McKenzie River are fluvial (migrating from rivers to tributary streams to spawn). Juvenile cutthroat rear for several years in the tributaries and then migrate to the mainstem McKenzie. Adults return to the tributaries in early spring to spawn. Other populations are resident, with adults remaining in their natal streams their entire lives. These resident cutthroat generally do not attain the size of the fluvial cutthroat.

Distribution in the McKenzie River Subbasin

Coastal cutthroat trout are the most widespread fish species in the McKenzie River Basin. They occur in most perennial streams, including areas above Tamolitch Falls, and are abundant in the lowest reaches as well. They are most numerous in the smaller tributaries and the upper portions of the mainstem. At times, they are the dominant trout species in the lowest reaches of the river.

Status

ODFW's List of Wild Populations includes 40 populations of resident cutthroat trout in the McKenzie Basin. The extent of most of these populations is unknown, but as most of the populations occupy limited and isolated habitat, they are assumed to be naturally small. Although timber harvest, road building and dams have altered habitat, the population trends of cutthroat are not well known. Most of populations are probably not threatened at this time.

Bull Trout (*Salvelinus confluentes)*

Bull trout historically occurred in Oregon in 11 basins of the Columbia River, plus the Klamath Basin. They were found in much of the Willamette Basin, including the entire McKenzie Basin. Today in western Oregon, bull trout are known to exist only in the Upper McKenzie and South Fork McKenzie, headwaters streams of the Klamath, and possibly the Middle Fork Willamette Basin. (Buchanan et al. 1997). They have apparently been extirpated from other Willamette tributaries (Ratliff and Howell 1992).

Life History

The bull trout is technically a char, closely related to Dolly Varden (*Salvelinus malma*), lake trout (*S. namaycush*), and brook trout (*S. fontinalis*). Bull trout are commonly classified as either river-dwelling (fluvial) or lake-dwelling (adfluvial). Fluvial forms are migratory within their resident river basin, using larger streams for foraging and rearing, and smaller tributaries for spawning and rearing. A fluvial population exists in the mainstem McKenzie River and its tributaries, primarily above Leaburg Dam. Adfluvial bull trout are adapted to hold and rear in lakes, spawning in small lake tributaries. Adfluvial populations have developed above the Cougar, Trail Bridge, and Smith dams as a result of their isolation from the mainstem population (Upper McKenzie River Watershed Analysis 1995).

Like other chars, bull trout spawn in the fall, between September and early November. Spawning sites are generally located in low-gradient riffles and runs of smaller tributaries. These sites consist of medium to coarse gravel (0.2–2 in.) in cool (42–46°F) water. Bull trout may compete for spawning grounds with fall-spawning salmon, including chinook in the McKenzie River subbasin. The spring-fed streams feeding the Upper McKenzie provide good spawning habitat for the species. However, many tributaries with favorable spawning sites were cut off from the mainstem McKenzie with the installation of impassable culverts during the construction of Highway 126.

Bull trout fry hatch out in the spring, and emerge from the gravel 2–3 weeks later. The young will spend from several months to 3–4 years in the tributary in which they were born. Sexual maturity is generally reached between years 3–6, and average life expectancy is 10-12 years. The average bull trout grows to a length of 12-18 inches and weighs 5-10 pounds.

Stream-resident young feed on adult and immature insects, leaches and snails, and, in the fall, salmon eggs. Rearing habitat includes low-velocity stream margins, side channels, and large wood accumulations. Adult bull trout are opportunistic feeders, and are known to be voracious predators of young salmon and trout. Fluvial bull trout in the Upper McKenzie use the mainstem channel, side channels, and lower reaches of tributaries for forage. Adfluvial populations forage principally in their resident reservoirs, as well as in the lower reaches of tributaries.

Distribution in the McKenzie River Subbasin

Three bull trout populations exist in the McKenzie River drainage: mainstem McKenzie up to Trail Bridge Dam, above Trail Bridge Dam to Tamolitch Falls, and above Cougar Reservoir on the South Fork McKenzie. Sub-adults have been found from below Leaburg Dam to about the Deerhorn Bridge, and a single adult was caught recently at the mouth of the McKenzie.

Status

Bull trout populations in western Oregon are assumed to have been in decline for several decades, although population monitoring data is lacking. Factors that have influenced this decline include habitat degradation from timber harvesting and road construction, loss of migration corridors, competition with non-native brook trout, and population loss due to angling.

The mainstem McKenzie population appears to be the most stable of the three. Key spawning and rearing streams (Anderson and Olallie creeks) are protected under USFS management. ODFW estimates that between 100 and 200 bull trout spawn annually in Anderson Creek, and predicts that the mainstem population will continue to grow in the future, and could seed other areas farther downstream.

The population above the Trail Bridge Dam is small (1998 ODFW estimate: 20 spawning adults), and is limited by a lack of adequate spawning and juvenile rearing habitat. The Highway 126 culvert at Sweetwater Creek was modified to allow bull trout passage in 1992, and bull trout fry were transferred to the creek in order to re-establish the population there. The effectiveness of these measures remains uncertain.

Above Cougar dam, the bull trout population is also relatively small (1998 ODFW estimate: 25-75 adults). Spawning and rearing habitat exists in the South Fork, Roaring River, and other smaller tributaries. Anglers are likely responsible for depleting large bull trout numbers in this area, despite the existence of a regulation requiring the release of all bull trout. Until recently, legal-sized rainbow trout have been released above Cougar Dam, and although they do not compete directly with bull trout, they do attract anglers to the area. ODFW has discontinued this practice in an attempt to reduce angling pressure on bull trout.

Mountain Whitefish (*Prosopium williamsoni*)

Mountain whitefish , a member of the family Salmonidae, are native to the McKenzie Basin, and are the most abundant game fish in the mainstem. Whitefish are a good sport and food fish, but they are not pursued as often by anglers as are the other members of the trout and salmon family.

Mountain whitefish are fall spawners. The fish do not dig redds, but instead broadcast eggs in riffle areas between October and December. Juveniles and adults generally stay near the bottom, where they feed on aquatic insects and other invertebrates. Whitefish prefer cold water, and are often found in fast currents. Little is known about trends in whitefish populations in the McKenzie River.

Other Species

Other native species in the McKenzie River include two species of lamprey, seven species of minnows, two suckers, the sand roller, the three-spine stickleback, and four species of sculpin (Table 2-7). Relatively little is known about the biology of most of these species. Lamprey, which have historically been an important Native American food source, are a species of concern in Oregon, but little is known about their populations in the McKenzie River.

Non-native species in the McKenzie include introduced brown trout and brook trout, summer steelhead (discussed in the rainbow trout section), the common carp, two species of bullhead, a mosquitofish, largemouth bass, and bluegill. Of these, brook trout, which compete directly with bull trout and cutthroat in the upper watershed, and largemouth bass, a predator in the lower watershed, pose the most serious threats to native species.

Future Trends for Fish Populations in the Study Area

Under current trends, wild spring chinook stocks appear to be under considerable pressure due to genetic mixing with hatchery stocks. Improvements in ocean conditions and declining fishing pressure have caused hatchery chinook numbers to soar recently, and with it, the greater propensity of genetic dilution among the last remaining wild fish. A number of salmon of hatchery origin are still allowed to spawn upstream of Leaburg Dam with the wild fish and an unknown number of unmarked "wild adults" may simply be unmarked hatchery fry that were introduced into Cougar reservoir, escaped, and then returned from the ocean. Wild chinook salmon spawning success should significantly increase in the South Fork of the McKenzie River following completion of the temperature control structure at Cougar Reservoir.

Bull trout populations should continue to experience modest increases due to recovery efforts of the last decade. Decreased fishing pressure, better access to traditional spawning areas, and stocking of Cougar Reservoir with salmon fry has allowed some local populations to increase rapidly. Nevertheless, dams continue to isolate bull trout populations in the McKenzie River, making each population vulnerable to sharp declines should local habitat quality decrease. Sub-adult bull trout have been found between Deerhorn Bridge and Leaburg Dam in recent years. When finished, the temperature control structure at Cougar Dam will increase water temperature in this reach during early summer. It is unclear whether or not these temperature increases would be sufficient to discourage bull trout use of the lower, warmer portions of the river.

Native rainbow and cutthroat trout populations are healthy in the McKenzie River, largely due to strict and enforced catch-and-release fishing regulations. The continued influence of stocked rainbow trout on wild trout remains unclear. These hatchery trout provide a fish for anglers to eat and this probably reduces illegal harvesting of wild trout. Considering that these hatchery fish are short-lived and do not appear to breed successfully, there is probably little risk of genetic mixing with the wild trout. Nevertheless, the addition of large numbers of hatchery trout to the river during the summer has the potential of locally displacing wild trout, at least until the hatchery trout are caught.

We expect that the future trends described above will be moderated by volunteer and mandated activities that improve water quality and fish and wildlife habitat in the McKenzie River watershed.

Detailed Recommendations for Conservation and Restoration of Fish Populations in the McKenzie River Subbasin

- Identify areas along the mainstem that could be restored to provide better off-channel habitat. Compare historical maps and aerial photos to current ones to identify the best areas. High-priority areas appear to be in Reaches 3 to 5 and 10 to 15, where restoration of side channel and island habitat could benefit chinook salmon and rainbow trout populations.

- Restore vegetative cover along the banks wherever possible. Stream margins with cover appear to be critical for the earliest life stages of chinook salmon.

- Encourage the US Army Corps of Engineers, if funding is available, to modify Blue River Dam so that water releases can be similar in temperature to natural water flows before the dam. The US Army Corps of Engineers is currently modifying Cougar Dam so that fall releases of water from the reservoir will be drawn from cooler water deeper in the reservoir, not from the warmer surface water.

- Minimize the introduction of hatchery chinook salmon into the McKenzie River, in order to maintain and expand the wild population. In recent years, over one million chinook hatchery smolts have been released annually into the McKenzie River, and this trend is projected to continue in the near future (Wade, M., ODFW, 2000, personal communication). The precise effect of this practice on the wild chinook salmon is unknown, but may be detrimental (American Fisheries Society 2000)

- Encourage ODFW to continue improving the accuracy of their wild chinook population assessment, and to reduce the introduction of hatchery fish into the river. In addition, ODFW should be urged to consider eliminating the practice of releasing chinook hatchery fry upstream from Cougar Dam.

- Encourage ODFW to examine the feasibility of limiting introductions of hatchery rainbow trout and steelhead into the McKenzie River. It is likely that hatchery rainbow trout and steelhead are negatively influencing the wild rainbow trout population. Also, encourage research on the degree to which wild and hatchery fish compete in the McKenzie River, and on the amount of interbreeding between wild and hatchery rainbow, and between wild rainbow and hatchery steelhead.

- Evaluate the McKenzie River subbasin to determine where housing development, logging, road building, and other potential impacts to cutthroat trout habitat are occurring.

- Evaluate the current condition of man-made structures that are potential fish barriers, such as road culverts. Determine where improvements can be made to allow fish migration, and encourage landowners and government agencies to carry out these improvements.

- Encourage ODFW to continue their monitoring of brook trout populations within the watershed. Also encourage ODFW to consider discontinuing the stocking of brook trout in mountain lakes, and not to issue permits to private landowners for the stocking of brook trout. It is probably not currently feasible to eliminate brook trout in the McKenzie River subbasin.

Priority Terrestrial Vegetation Types

Background

Humans and natural forces have shaped the distribution of plant communities in Western Oregon for hundreds of years. The McKenzie River subasin consists of two main geographic areas, each with distinct terrestrial vegetation types and histories. In the lower basin, including the area of the confluence between the McKenzie and Willamette Rivers and along the mainstems of the McKenzie and Mohawk Rivers, terrestrial vegetation types were representative of those found in the Willamette Valley (Appendix 4, Figure 5). Studies of historic vegetation patterns in the Willamette River basin characterized the valley floor as a mosaic of prairies, oak savannas, and wetlands with a wide gallery forest along the main stem of the river that was dominated by cottonwoods and Oregon ash (Johannessen et al. 1971, Towle 1982). Allen et al. (1999) report that before arrival of European settlers, the Willamette Valley was comprised of 52% oak savannah and dry prairie, 27% mesic bottomland prairie (swampy grasslands), 11% upland forest (including open Douglas-fir stands), 10% bottomland riparian forests, and 1% wetland. These studies report that grassland, oak savanna, and open upland forest plant communities were maintained, in part, by wildfires set by the Kalypua for purposes of hunting and food gathering. European settlers did not continue this practice, and grasslands had noticeably begun succeeding to closed-canopy oak woodlands and conifer forests by the end of the 1800's (Boag 1992).

Early Willamette Valley farmers began ditching and tiling along the floodplains of the Willamette and tributaries to improve agricultural fields and to build roads. Gallery forests composed of black cottonwood, Oregon ash, Oregon white oak, Douglas-fir, and ponderosa pine supplied firewood for settlements and river boats. Agricultural practices, forest cutting, river channelization, urban development, and altered succession patterns have continued to change the structure and composition of plant communities in the Willamette Valley and surrounding foothills. Native prairies and oak savannas were once widespread, but have been reduced by 88% and exist only as isolated fragments throughout the Valley (Allen et al. 1999). Bottomland prairies have been reduced by 99%, bottomland riparian forests by 72%, and wetlands by 58% (Allen et al. 1999). In addition, the amount of open water that once occurred as ponds, sloughs, and oxbow lakes has been significantly reduced; over half of the tributary and slough reaches along the Willamette River were lost between 1850 and 1932 (Allen et al. 1999).

Most of the remaining intact habitat in the Willamette Basin exists in the uplands of the Coast and Cascade Ranges (Allen et al. 1999). Terrestrial vegetation in areas upland from the main river stems are dominated by conifer forests. European-American settlers, miners, trappers, and loggers began influencing forest vegetation beginning in the mid-1880's. Dominant practices that altered patterns of terrestrial vegetation in the uplands includedlogging, gold-mining, ranching, development, fire control, and building of dams (Lane Council of Governments 1996, USDA Willamette National Forest, USDI

Salem District BLM, USDI U.S. Fish and Wildlife Service OSO 1998). Logging and road-building during the latter half of the 1900's probably had the most influential effect on vegetation in the uplands. In the mid-1990's, forests in the uplands were dominated by late-seral conifer forests whereas early to mid-seral conifer forests now dominate the uplands (USDA Willamette National Forest, USDI Salem District BLM, USDI U.S. Fish and Wildlife Service OSO 1998). Most of the remaining late-seral and old-growth forest is located in the upper McKenzie Basin on lands managed by the U.S. Forest Service and BLM and is located within wilderness areas or Late-Successional Reserves (Lane Council of Governments 1996, USDA Willamette National Forest, USDI Salem District BLM, USDI U.S. Fish and Wildlife Service OSO 1998).

Data collection

To map current and historic distributions of priority vegetation types, we reviewed data and maps from several sources, including:

- The Oregon Gap Project
- Oregon Department of Fish and Wildlife Willamette Valley Habitat Map
- Oregon State University, Department of Forest Science thematic-mapper imagery
- Oregon Biodiversity Project
- National Wetlands Inventory
- McKenzie floodplain map prepared for this project

We evaluated each data set and map according to extent of coverage, metadata availability, minimum mapping unit size, and classification scheme for vegetation structure and species composition. No single data source was found to adequately represent the distribution of wetlands, riverine cottonwoods, and oak woodlands for the purpose of this assessment. Thus, we relied on different data sets to construct maps independently for each vegetation type. Maps were prepared as GIS polygon themes for analysis in *Arcview*® and merged with a theme of 6th-field watershed boundaries prepared by Alsea-Geospatial. We used the following methods to prepare each theme:

Ponds, wetlands and riverine forests

We used digitized 1:24,000 scale National Wetland Inventory (NWI) maps as the primary data source for locations of palustrine and lacustrine wetlands. NWI maps typically are based on aerial photography conducted during the period 1975-1990. The spatial extent of the NWI data included the Springfield metropolitan area and sub-watersheds that are tributaries to the Mohawk River and Camp Creek. Descriptions of wetland classes and other terms used are presented in Appendix 2A. None of the maps we reviewed included a separate species class that permitted us to specifically locate black cottonwood stands. As an alternative, we used the McKenzie River reach landcover map prepared for this assessment to create a GIS theme of polygons containing mature stands (age >39 years) of combined hardwood species that comprise the river-side forests.

Oak woodlands

We merged data from two sources to create a base map of oak woodlands in the lower watershed. Oak and mixed oak / conifer woodlands were identified in the delineated reaches along the McKenzie floodplain from the digitized reach landcover map. Upland patches of oak woodlands beyond the delineated river reaches were identified from the ODFW Willamette Valley Habitat Map. Both data sets were constructed from interpretation of aerial photographs. An examination of a preliminary base map of combined polygons indicated that some intersecting areas of the two maps were classified differently by the two sources. To verify locations of oak woodlands in the lower watershed, we conducted an aerial videography mission to examine all oak polygons identified by both sources (Appendix 4, Figure 7). A secondary objective of the mission was to conduct a reconnaissance for oak woodlands not represented on either map in sub-basins in which oak woodlands and savannas were common in the period of European settlement. The final oak woodland map includes delineated polygons from both original data sources with polygon classifications modified after observations made during the videography flight.

Pre-settlement vegetation

We used a pre-settlement vegetation layer compiled by the Oregon Natural Heritage Program (ONHP) to characterize a historical distribution pattern of prairies, savannas, woodlands, and riverine forests. The ONHP map was created using observations recorded by surveyors during the original Government Land Office (GLO) survey of the Willamette Valley in the 1850's and 1860's (Christy et al. 1997) The spatial extent of the GLO map did not include complete coverage of 6th-field watersheds above Camp Creek. However, we assume that most of the upper watershed was dominated by closed-canopy, conifer forests during the period of settlement. Differences in the spatial extent and vegetation classes between the current land cover and GLO survey map do not permit a quantitative comparison. Therefore, we have relied on graphical comparisons of landscape-scale patterns between current and past vegetation distributions.

Vegetation Findings

Ponds and wetlands

Lacustrine and palustrine wetlands are most extensive on the McKenzie River floodplain near the confluence with the Willamette River (Appendix 4, Figure 8). Three delineated reaches (Reaches 0-2) in this region contained approximately 30% of total wetland features mapped on the McKenzie floodplain (Table 2-8). This estimate does not include gravel pits near the confluence that may provide additional habitat for some vertebrate species. Two other significant features on the floodplain are a constructed pond in Reach 11(T17S R2W S28) and the Walterville Reservoir. Major palustrine wetlands on the McKenzie floodplain are located in Reach 12 (T17S R2W S27 and 26) near the Willamette River, Mohawk River, and Camp Creek confluences (Appendix 4, Figure 8). Extensive areas of wetlands also occur along tributaries to the McKenzie. The 6th-field sub-basin with the greatest acreage of wetlands occurs in the lower Mohawk River watershed (Table 2-11).

Riverine hardwood forests

The total area of mature hardwood forest on the McKenzie reach landcover map was estimated to be 1109 acres (Table 2-8). Hardwood forests along the lower McKenzie floodplain are most extensive at three locations: near the confluence with the Willamette River (Reaches 1 and 2), Reaches 5-6 near Armitage Park, and Reaches 11-12 in the vicinity of Cedar Creek (Appendix 4, map 6). A graphical comparison of mapped riverine forests between the current condition and the period of 1850-1860 (Appendix 4, Figure 5) indicates that a considerable degree of forest loss and fragmentation has occurred on the McKenzie floodplain below the Camp Creek confluence during the last 150 years. The GLO Survey map shows an uninterrupted riverine forest along the lower McKenzie, varying in width between 1000-4000 feet. Near the Willamette confluence and Springfield metropolitan area, much of the original gallery forest has been converted to agricultural or developments, and closed-canopy forests generally exist only as isolated patches. Loss of riverine forest between Camp and Quartz Creeks appears to be mainly due to clearcut harvesting; approximately 18% of closed-canopy forests along this section existing in 1990 have been clearcut during the last 10 years. Loss of older conifer- and hardwood-dominated forest is of concern because these forests provide key habitat for many species of wildlife, including many that were determined to be of special concern in this report. In 1944, older (>80-year-old) conifer and hardwood forests were present below reach 27 where at present they are absent. Older hardwood forests appear to be absent throughout the lower watershed; older conifer forests are restricted to areas above reach 29 (near the confluence with Bear Cr.; Figures 2-27 and 2-28).

Table 2-8. Current extent (acres) of priority vegetation types in delineated McKenzie River reaches.

Reach Number	Wetlands [1]	Mature Hardwoods[2]	Oak woodlands
0	44	11	0
1	215	125	0
2	158	123	5
3	8	0	0
4	16	3	0
5	81	108	31
6	67	172	113
7	45	128	128
8	10	121	121
9	17	51	155
10	44	0	7
11	119	69	488
12	92	45	79
13	6	3	7
14	27	0	28
15	31	3	5
16	23	6	6
17	128	0	0
18	18	0	18
19	8	0	15
20	18	11	0
21	19	19	0
22	9	1	0
23	26	14	0
24	16	0	0
25	13	0	0
26	10	0	0
27	0	0	0
28	8	0	0
29	0	0	0
30	3	0	0
31	0	0	0
32	0	0	0
33	24	21	0
34	64	63	0
35	0	0	0
36	0	0	0
37	17	12	0
Total	1384	1109	1206

[1] Natural ponds, off-channel reservoirs, alcoves, and side channels.
[2] Hardwood dominated landscape patches, stand age >40 years.

Oak woodlands

Oak woodlands are relatively uncommon on the current landscape (Appendix 4, Figure 7). Our survey identified 93 patches amounting to a total of 1942 acres in the Mohawk watershed and along the McKenzie floodplain below Camp Creek (Table 2-11). Approximately 25% of the total area of oak woodland occurred as a single patch in the Springfield sub-basin. This patch appeared to be recently harvested and oaks were widely scattered among grass and brush in a pattern similar to savanna. Oak woodlands are particularly rare on public lands in the lower McKenzie watershed. An extensive inventory conducted on the BLM McKenzie Resource Area in 1998 did not find any stand larger than 5 ac (Chiller and Vesely 2000). Pure oak woodlands may never have been common in the western Cascade foothills. The GLO map indicates approximately 8785 ac of woodlands and 5865 of savannas in the lower watershed during the 1850's (Appendix 4, Figure 5). Oregon white oak was common in the composition of these plant communities, but stands were often mixed with Douglas-fir, ponderosa pine, and other hardwood species (Franklin and Dyrness 1988). Most oak woodlands that exist today have developed from prairies and savannas that have developed after European settlers interrupted the Native American practice of annually burning these areas (Thilenius 1968). Forest succession continues to shape species composition of these stands and oak woodland and savanna communities usually develop into closed-canopy Douglas-fir forests in the absence of disturbance such as wildfire (Franklin and Dyrness 1988).

Avian Species of Concern in the McKenzie Basin

Background

A wildlife issue identified by the McKenzie Watershed Council is determining the role the McKenzie River subbasin has in providing habitat for migrating birds. Because many species of neotropical migrants, other migrants (such as waterfowl and shorebirds), wintering birds, and residents use the same types of habitat, and since conservation actions will benefit both residents, migrants, and wintering birds, we expanded our analysis to other avian taxa distributed in the watershed.

Methods

We used Csuti et al. (1997), to derive a list of species that breed or winter in the McKenzie Basin. We excluded species whose range is mostly on the east side of the Cascade Range but also on the west side only at the crest of the McKenzie Basin. For species that breed in the McKenzie basin, trend analysis was conducted using Sauer et al. (2000) for the: 1) Cascade Mountain Region, 2) Willamette Basin Region, and 3) Oregon. All species that were significantly declining (P<0.1), either on a short- (1980-1999) or long-term (1966-1999) basis, in any of the three regions is considered as Species of Concern. For species that winter in the McKenzie Basin, trend analyses were conducted using Sauer et al. (2000) for the appropriate area representing the breeding range of the species. In addition, analyses were conducted to examine trends in wintering populations in Oregon based on Christmas Bird Count data (Sauer et al. 1996). Species with declining trends (P<0.1) in either wintering or breeding populations were considered as Species of Concern (Appendix 2B).

Habitats, life history traits, range within the McKenzie Basin, migratory status, and historical population status in the Willamette Valley and the foothills of the Cascades was described for each Species of Concern using Marshall et al. (in prep), Csuti et al. (1997), and Gullion (1951; Appendix 2C).

Historical population status was taken directly from Gullion (1951). He summarized data from a 775 square mile area of the Willamette Valley from approximately Junction City to Cottage Grove and from Elmira to Marcola and Walterville. Field notes from field surveys by the author and from additional experienced naturalists were summarized. He defined populations as follows:

Abundant: recorded on 70% or more of possible record days
Very common: recorded on 45 to 69% of possible record days
Common: recorded on 18 to 44% of possible record days
Uncommon: recorded on 6 to 17% of possible record days
Rare: recorded on less than 6% of possible record days.

We could not find comparable historical data regarding populations of the Species of Concern in the Cascade Range. However, since Gullion's surveys did include the foothills up to Walterville and Marcola, and many of the species that normally are found in the Cascades are included in Gullion's paper. Population levels for many of these species are lower than what would be expected in the Cascades because the area sampled only covered the fringes of their normal range.

The geographic range within the McKenzie Basin was described for each Species of Concern. Each species was noted as occurring in the Cascades, Willamette Valley, or Cascades and Valley. Some species have additional notations indicating that they breed in the Cascades and winter in the Valley or indicating that they historically occurred in the Cascades or Valley.

The migratory status of each species was also noted. Each species was noted as a resident, neotropical migrant, other migrant, or basin migrant. Residents are species that occur throughout their range in both summer and winter, and includes species that remain on their home range year-round and species that migrate short distances such that different individuals occur in an area in different seasons. Neotropical migrants are species that breed in the McKenzie basin during summer and winter south of the United States. Other migrants include species that breed elsewhere and that move into the McKenzie Basin during winter and species that breed in McKenzie basin during summer and winter in areas north of Mexico. Basin migrants include species that breed in the Cascades and winter in the Willamette Valley.

We described important habitats for each Species of Concern (Appendix 2D) and grouped species together based on their habitat associations (Table 2-9). Species that are strongly associated with more than one habitat type are listed under each habitat category.

Avian Species Findings

Oak woodlands and savannahs

Seven Species of Concern occur in oak woodlands or oak savannahs. One species, the Lewis' woodpecker formerly nested in oak/pine savannas of the Willamette Valley but has been extirpated due to loss of habitat (Altman 2000). Acorn woodpeckers, chipping sparrows, western bluebirds, Lewis' woodpeckers, and American kestrels are closely associated with open oak savannahs; all but the chipping sparrow require oaks large enough to have large-diameter limbs for nesting. White-breasted nuthatches and black-capped chickadees are associated with closed-canopy oak stands and require large-diameter limbs for nesting; white-breasted nuthatches are closely associated with large-diameter oaks (Hagar and Stern in review, Altman 2000).

Although they once were common in the lower McKenzie Basin, we find no evidence that functional oak savannas (i.e., scattered oaks with a native grassland understory; maintained by fire) remain in the watershed. The closest habitat resembling oak savannahs is scattered large-diameter, open-grown oaks that occur on agricultural lands. Most of the remaining closed canopy oak woodlands occur in the lower basin and are on privately owned lands. The amount and quality of oak woodlands have declined considerably in the past 100 yrs. Loss of oaks to development, agricultural uses, and encroachment of conifers is of particular concern to avian conservationists (Altman 2000). Loss of large-diameter oaks is of concern because small-diameter trees have too small of branches to provide adequate size of limbs for use by cavity-nesting birds. Large-diameter, open-grown oaks with a spreading growth form are particularly important for wildlife even if they occur singly or in small patches. These oaks provide a complex, large canopy, large-diameter limbs, and a unique habitat that cannot be easily replaced or compensated for with smaller oaks. In addition, these oaks have high esthetical value. Regeneration of oak woodlands has been poor and is partly explained by the inability of oaks seedlings to survive under dense cover of conifers and non-native shrubs such as Himalayan blackberry. Oak woodlands that are near urban areas may have high numbers of European starlings that compete for cavity resources with native birds (Altman 2000).

We suggest that the McKenzie Watershed Council consider guidelines developed for Partner's in Flight (Altman 2000) as a basis to guide conservation actions for oak woodlands in the McKenzie Basin. The areas with the greatest opportunities for oak preservation and restoration are in the Springfield, Lower Mohawk, and Cedar Creek watersheds (Table 2-10). Existing high-quality oak stands should receive the highest priority for conservation/restoration activities. The highest quality oak stands are the largest stands and those with minimal encroachment of conifers or non-native shrubs. Large open-grown oaks with a spreading growth form and large-diameter limbs are of particular importance, even if they are located singly or in small patches. We recommend that the Watershed Council take an active role to educate landowners as to the importance of these large oaks to wildlife.

We recommend the following conservation actions for oak-woodlands and savannahs (based in part on recommendations in Altman 2000):

1) Support a policy of "no net loss" of oak woodland habitats: mitigate loss of oak woodlands with greater or equal restoration efforts
2) Preserve existing high quality oak woodlands; high quality oak woodlands include
    a) Large patches of oaks
    b) Oak woodlands with minimal encroachment by conifers
    c) Patches that include healthy, large-diameter "open grown" oaks.
    d) More open oak woodlands; these will be more easily restored to a savannah-like habitat
3) Support preservation efforts by private land-owners of all large-diameter, open-grown oaks
4) Encourage restoration efforts of degraded oak habitats (below are possible restoration activities)
    a) Remove conifers and maples
    b) Thin oaks to make stands more open
    c) Underplant to provide young, subcanopy oaks
    d) Remove non-native shrubs such as Himalayan blackberry and Ivy

Table 2-9. Important habitats for Avian Species of Concern in the McKenzie Basin.

Oak Woodlands	**Conifer Forests**	**Variety of habitats**
Lewis' Woodpecker	Vaux's Swift	American Crow
Acorn Woodpecker	Swainson's Thrush	American Robin
White-breasted Nuthatch	Cooper's Hawk	Barn Swallow
Western Bluebird	Northern Goshawk	Brewer's blackbird
Chipping Sparrow	Northern Pygmy-owl	Cedar Waxwing
American Kestrel	Spotted Owl	Cooper's Hawk
Black-capped Chickadee	Great Gray Owl	Mourning Dove
	Chestnut-backed Chickadee	Pacific-slope Flycatcher
Grasslands	Red-breasted Nuthatch	Violet-green Swallow
Common nighthawk	Brown Creeper	Western Wood Pewee
Vesper Sparrow	Golden-Crowned Kinglet	Western Tanager
Savannah sparrow	Pileated Woodpecker	
Golden Eagle	Varied Thrush	
Burrowing owl	Band-tailed Pigeon	
Killdeer	Pine Siskin	
Great gray owl	Purple Finch	
Horned lark		
Western Bluebird	**Shrub Habitats**	
Chipping Sparrow	Rufous Hummingbird	
Western Meadowlark	Orange-crowned warbler	
Lesser goldfinch	Nashville Warbler	
Grasshopper Sparrow	MacGillvray's Warbler	
	Wilson's Warbler	
Riparian Woodlands	Fox Sparrow	
Yellow-billed Cuckoo	Song Sparrow	
Willow Flycatcher	White-crowned Sparrow	
Red-eyed Vireo	Lesser Goldfinch	
Yellow-breasted Chat	American Goldfinch	
Lewis' Woodpecker		
Downy Woodpecker	**Unique Habitats**	
Black-capped Chickadee	Olive-sided Flycatcher	
	Black Swift	
Bodies of Water		
Purple Martin		
Black-crowned Night-Heron		
Northern Pintail		
Harlequin Duck		
Common Goldeneye		
Osprey		
Bald Eagle		
Belted Kingfisher		

Table 2-10. Special habitat features required by avian Species of Concern.

Snags Vaux's Swift Violet-green Swallow Purple Martin Northern Pygmy-owl Great Gray Owl Pileated Woodpecker Lewis' Woodpecker Acorn Woodpecker Downy Woodpecker Black-capped Chickadee Chestnut-backed Chickadee Red-breasted Nuthatch White-breasted Nuthatch Brown Creeper Western Bluebird American Kestrel	**Singing Perches** Western Meadowlark **Mineral Sites** Band-tailed Pigeon **Old Trees/Snags near water** Bald Eagle Osprey **Embankments** Belted Kingfisher
Logs Pileated Woodpecker	
Burned Areas Lewis' Woodpecker	
Flowering Plants Rufous Hummingbirds	
Seed-producing plants Red-breasted Nuthatch (conifer) Pine Siskin (conifer) American Goldfinch (Aster sp.) Lesser Goldfinch (Aster sp.)	
Waterfalls/ Cliffs Barn Swallow (cliffs or houses) Black Swift (waterfalls)	

Grasslands

Thirteen Species of Concern occur in grasslands. Because their range is restricted to valley grassland habitats, the vesper sparrow, savannah sparrow, burrowing owl, golden eagle, western meadowlark, and grasshopper sparrow should receive the highest conservation priority. The common nighthawk, killdeer, western bluebird, chipping sparrow, and lesser goldfinch can also be found in a variety of habitats including meadows and grasslands higher in the basin. The great gray owl is found in meadows and mature forest areas with adjacent openings only at the higher elevation areas of the east end of the basin. Many grassland species require either special habitat features or special types of grasslands. For example western bluebirds require nest cavities, chipping sparrows require trees or tall shrubs, lesser goldfinches require shrubs for nesting, and meadowlarks and vesper sparrows require singing perches. The common nighthawk and horned lark prefers short grasses with patches bare ground whereas the western meadowlark prefers taller grasses (see Appendix 2D for full description of habitats used by each species).

The greatest change in vegetation of the Willamette Valley has been the near extirpation of what was once the most abundant plant community, native grasslands. Less than 1% of native grasslands remain in the Willamette Valley; causes of loss are conversion to agriculture, invasion of non-native species, and enhanced natural succession due to fire suppression (Altman 2000, Allen et al. 1999). Grassland birds do use human-created grasslands including actively managed and abandoned agricultural grass fields, pastures, and very young Christmas tree farms with a grass understory. However, the ability of grassland birds to co-exist with actively managed grass fields and pastures depends on both the timing and the intensity of the management activities.

Although very little of the McKenzie Basin contains grassland habitats, the McKenzie Basin still has great potential to contribute habitat for this group of species. Some of the Willamette valley's most threatened birds, including our state bird, the Western Meadowlark, are grassland birds. Grassland birds are unique from other landbirds in that many species can benefit from careful uses of agriculture or grazing (Altman 2000, Oregon Department of Fish and Wildlife 2000). Because of this, private landowners are in a good position to assist in managing habitats for grassland-associated birds. We suggest that the McKenzie Watershed Council consider the guidelines in Partner's in Flight's "Conservation strategy for landbirds in lowlands and valleys of western Oregon and Washington" (Altman 2000) and "Landowner's Guide to creating grassland habitat" (Oregon Department of Fish and Wildlife 2000) as a basis to guide conservation actions for grasslands in the McKenzie Basin. We suggest encouraging private landowners who own grasslands and use them for agriculture or grazing to consider the guidelines listed below to benefit grassland birds.

Very little information exists describing what species of grassland birds actually nest or winter in the McKenzie Basin. A systematic survey of potential grassland habitats in the McKenzie Basin is needed to determine which species nest in the basin and to further identify important characteristics of the grasslands that they use. In addition, because satellite coverage does not distinguish among different grassland plant communities, it is uncertain where grasslands with a high potential for conservation or restoration actually occur. We recommend that systematic searches be conducted to map and describe existing grassland habitats and to survey for grassland birds in those habitats. The Cedar, Springfield, and Lower Mohawk 6th field watersheds are the most likely watersheds to contain suitable grasslands for conservation or restoration (Table 2-11). In addition, a population of Vesper Sparrows, a rare grassland bird species, is known to occur in the area of Coburg Ridge, which includes portions of the Springfield and Lower Mohawk 6th field watershed.

We recommend the following conservation actions for grasslands (based, in part, on Altman 2000 and Oregon Department of Fish and Wildlife 2000):

1) Preserve existing high quality grasslands and actively manage them to promote sustainability. Different types of grasslands represent high quality habitat for different species of birds (see Appendix 2D), Altman 2000, and Oregon Department of Fish and Wildlife 2000). The highest quality grasslands will have some of the following characteristics:
    a. Occur in large patches (> 200 acres)
    b. Contain native grass species
    c. Contain existing populations of grassland birds (such as the Coburg Ridge)
    d. Have a variety of grass species or heights of grasses
    e. Have scattered shrubs, fence-posts, or other suitable structures for singing perches
    f. Are ungrazed and unmanaged or actively managed in a manner that is compatible with grassland birds (see below)
2) Improve quality of degraded grasslands by
    a. Removing of non-native shrubs
    b. Restoring to native grass species
    c. Adding singing perches
    d. Mowing, grazing, or burning to reduce encroachment of woody growth, increase grass vigor, and reduce weeds

We recommend that the McKenzie Watershed council encourage private landowners to provide habitat for at least one of the very sensitive species of grassland bird (western meadowlark, horned lark, vesper sparrow, or grasshopper sparrow). See Appendix 2D, Altman (2000), and Oregon Department of Fish and Wildlife (2000) for a description of the habitat conditions needed by various species.

Riparian woodlands

Seven Species of Concern use riparian woodlands; all but the downy woodpecker and black-capped chickadee are more highly associated with bottomland riparian woodlands of the Willamette Valley than with riparian woodlands of the Cascades. The red-eyed vireo and Lewis's woodpecker formerly occurred in stands with large-diameter cottonwoods and the yellow-billed cuckoo in a variety of riparian habitats but especially in large patches of willows. These species no longer occur in the Valley; their extirpation probably was due to habitat loss. The yellow-breasted chat and the willow flycatcher occur most frequently in shrubby riparian habitats such as in patches of willows. The downy woodpecker and black-capped chickadee occur in a variety of riparian habitats and require dead trees or large-diameter dead limbs for nesting.

In the Willamette Valley, black cottonwood, Oregon ash, and willow are dominant riparian species. In the foothills and Cascades, big-leaf maple and red alder are the dominant riparian hardwood species whereas Douglas fir and red cedar are common conifer species. Much of the riparian woodlands in the Willamette Valley have been lost and those that remain have been highly changed from pre-settlement conditions. Primary causes of loss have been flood control and development for agriculture. In the Valley, less than 3% of the riparian woodlands remain today (Allen et al. 1999). Of particular concern is the loss of gallery cottonwood, Oregon ash, and willow groves. The status of riparian habitats in the foothills and Cascades is less certain, but appears not to be threatened due to increasing forest practices protection. Priorities for conservation should begin with existing high-quality riparian woodlands. Woodlands with large-diameter cottonwoods should receive the highest priority. Large patches of riparian woodlands, regardless of species composition, but especially those containing a large component of cottonwoods or willows should receive conservation priority.

Very little information exists regarding avian communities in riparian forests, especially Oregon ash forests, of the Willamette Valley. Since many Species of Concern seem to be highly associated with riparian forests, we suggest that more research be conducted regarding the role of riparian forests in providing habitat for avian species of concern. In addition since we were unable to distinguish large-diameter cottonwoods from other hardwood species based on GIS data, an intensive aerial photo survey is necessary to conclusively identify locations of large-diameter hardwood riparian woodlands.

We recommend the following conservation actions for riparian woodlands (based, in part, on Altman 2000):

1) Preserve existing high quality riparian woodlands comprised of native species. High quality riparian woodlands:
    a. Are large in size (> 50 acres)
    b. Contain large-diameter (> 22 in) cottonwoods
    c. Contain an understory of ash or willow
2) Improve quality of degraded riparian woodlands by
    a. Restoring hydrological processes, where possible
    b. Planting of native trees and shrubs
3) Maintain buffer zones of > 100 ft wide

When alteration of existing vegetation is deemed necessary, conducting projects outside the breeding season (April 15 to July 31) should be done when possible. Restoration of areas near existing riparian woodlands should receive priority over areas far from existing woodlands.

The NF Gate Creek, Tom Finn, Cedar, Weyhawk, and Lower Mill Creek 6th field watersheds contain the highest acreage of forest closed-canopy hardwood forest (Table B7). Specific to the floodplain, the total area of closed-canopy forest in the mapped river reaches is 18,863 acres; 1107 acres of these are mature hardwood stands (Table 2-8). Hardwood forests along the lower McKenzie floodplain are most extensive near the confluence with the Willamette River (Reaches 1 and 2) and between I-5 and the confluence with the Mohawk River (Reaches 5-8) (Appendix 4, Figure 6). Willows occur mostly in lower 1/3 of the study area and in flood-prone areas (figure 2-27).

Limnetic features and wetlands

Eight species of concern use wetlands and bodies of water for nesting, feeding, or both. Five species breed in the McKenzie basin whereas 3 occur only in winter. The osprey and bald eagle require large bodies of water and occur along the major rivers and reservoirs. The Harlequin duck breeds and feeds in smaller 3rd to 5th order streams; the belted kingfisher occurs along a variety of sizes of water, but is most common along rivers, large streams, and reservoirs. The purple martin forages over rivers, lakes, and marshes and often nests near water. The northern pintail and black-crowned night heron occur in marshes; common goldeneyes require open water such as rivers, lakes, or ponds.

Much of the open water and wetlands that once occurred in the Willamette Valley have been lost through filling or draining. Much of the open water habitat losses occurred in secondary channels, sloughs, ponds, and oxbow lakes; loss of tributary and slough habitat in the upper reach (which includes the lower McKenzie River subbasin) is estimated at 84% (Allen et al. 1999). Currently, alcoves, ponds, and side channels occur mostly in the lower one-half of the McKenzie River subbasin. Reach 17 contains the highest value for side channels; in this area a large island splits the channel (see section on channel complexity).

We suggest that the osprey and bald eagle continue to receive special consideration for conservation actions and that conservation actions for these species should focus on retaining as many large-diameter trees (especially conifers) and snags adjacent to major rivers and reservoirs as possible. Large-diameter conifers and hardwoods will likely occur within patches of older seral-forest, although they can occur singly. Currently, older conifer forest is located above the Leaburg Dam (Figure 2-27).

Restoration of wetlands, sloughs, ponds, and oxbow lakes will benefit many of the species listed above as well as fish, pond turtles, and other species of wildlife. Conservation and restoration of these habitats should be focused in the lower basin. Most of the remaining wetlands occur in the lower basin, in the Cedar, Springfield, and Lower Mohawk watersheds (Table 2-11). Specific to the floodplain, wetlands are most common in Reaches 1-2; significant wetlands also occur in Reaches 11 and 17 (Table 2-8). Older conifer trees near the McKenzie River may provide nest sites for bald eagles; significant amounts of older conifers occur in and above reach 30 (Figure 2-27).

Conservation of wetlands, ponds, alcoves, or side channels will benefit avian Species of Concern, pond turtles, fish, and many other species of wildlife. We suggest that the McKenzie Watershed council utilize existing resources and engage in active partnerships with other conservation-groups when developing a conservation plan for wetlands (see Conservation Partnerships and Educational Opportunities Section).

Conifer forests

Fifteen species of concern occur in conifer forests. Twelve of these species (Vaux's swift, northern goshawk, spotted owl, northern pygmy-owl, great gray owl, pileated woodpecker chestnut-backed chickadee, red-breasted nuthatch, brown creeper, golden-crowned kinglet, varied thrush, and pine siskin) are most abundant in older seral stages. The Vaux's swift, northern goshawk, and spotted owl are highly associated with old-growth forests. The great gray owl only occurs in the upper reaches of the basin at high elevations. Swainson's thrushes prefer dense conifer forests and often occur near riparian areas whereas purple finches avoid dense forests and often occur near edges. Band-tailed pigeons nest in closed-canopy conifer forests but forage in open canopy forests. Vaux's swifts, pileated woodpeckers, northern pygmy-owls, chestnut-backed chickadees, red-breasted nuthatches, and brown creepers require snags for nesting; the spotted and great gray owls will also use, but don't require snags for nesting.

Whereas late seral forest used to be common and scattered across the basin, it now covers less than 30% of the watershed and in concentrated in areas high in the basin (Lane Council of Governments 1996). Most of the conifer-associated Species of Concern are associated with older conifer forests, and their population decline may be due, in part, to the loss of older forests. The US Forest Service or Bureau of Land Management administers approximately 68% of the basin; most of the conifer forest on public lands is now reserved from timber harvest (Lane Council of Governments 1996).

The Watershed Council may have opportunities to encourage management practices on privately owned conifer forests that will benefit avian Species of Concern. Retention of snags and live trees, partial cutting or limiting clear-cutting to small areas, and retention of buffer strips would be beneficial to many species of concern and should be encouraged. The Oregon Forest Practices Act (Oregon Department of Forestry 1996) already has established some of these standards for harvest units that are > 25 acres in size. We recommend that the McKenzie Watershed Council encourage landowners to follow the guidelines as established by the Oregon Forest Practices Act on harvest units that are < 25 acres and to exceed the minimum standards as required by law (i.e., leaving more than the 2 snags or live trees per acre that are required by law). These management actions should benefit avian species of concern, fish, pond turtles, and other types of wildlife.

Shrub habitats

Ten Species of Concern use shrub habitats. Many of these species will use a variety of shrub habitats, regardless of their location, but are most common in particular areas. Nashville warblers, MacGillvray's warblers, and white-crowned sparrows prefer open brushy areas with little to no overstory cover. Orange-crowned warblers, song or shrubs near riparian areas. Wilson's warblers and rufous hummingbirds prefer shrubs within forested areas; rufous hummingbirds prefer shrubs under a tall, open overstory.

The McKenzie Basin likely contains many acres of shrub habitats in the form of shrubby clearcuts throughout the Basin. However, riparian shrub habitats have declined (Allen 1999) and may be of particular importance to both shrub-associated and riparian woodland-associated Species of Concern. We strongly encourage restoration of riparian shrub thickets (especially willows; see Riparian Woodland section). This type of restoration will not only benefit many avian species of concern, but will also benefit fish and other types of wildlife.

Unique habitats

Two species of birds, the olive-sided flycatcher and black swift, occur in unique habitats. The olive-sided flycatcher prefers high-contrast edges such as edges between forests and meadows, recent clear-cuts, bodies of water such as lakes, ponds, or rivers. Optimal habitat in one study in the Cascade Range appeared to be early-seral forests with scattered trees or snags (Altman 1999).

Very little information exists as to the causes of population declines of olive-sided flycatchers or for conservation actions to remedy those declines. However, we feel that the guidelines suggested by Altman (1999) provide a good starting point and are reasonable actions that the Watershed Council could encourage landowners to follow.

For edge habitats for olive-sided flycatchers, Altman (1999) suggests the following conservation actions:

1) Retention of > 3 clumps that are about 2.5 acres in size and contain 4 to 12 trees per acre
2) Retention of scattered trees (1 to 2 per acre) throughout the rest of the stand.
3) etained trees should be at least 50% true firs or western hemlocks to provide preferred nest trees and have at least 25% live foliage in the crowns.

Table 2-10. Total area (ac) of potential habitat-types in sixth-field watersheds of the lower McKenzie Basin; some habitat types contain coverage of other non-suitable habitat types and are listed below. The highest 5 values for each category are shown in bold type. (see Appendix 4, Figure 17 for locations of watersheds).

	Oak woodlands	Grassland			Riparian Woodland	Aquatic / Semi-aquatic	
Watershed	Oak woodlands	Pasture/natural/ x-mas tree farm[1]	Bare/ fallow[2]	Field crop[3]	Closed-canopy hardwood	Wetlands[4]	Open[4] Water
Bear Composite	0	109	8	1	486	5	77
Camp Crk.	**52**	**1623**	**32**	**409**	760	76	1
Cartright Crk.	0	207	3	17	190	16	0
Cedar	**335**	**4110**	**153**	**795**	**1472**	**734**	**272**
Deer	0	1	0	0	586	0	0
Drulog	0	749	17	14	737	75	0
Ennis	0	1	0	0	499	0	0
Holden Hagen	0	751	11	**201**	910	16	**88**
Leaburb Canal	0	543	**24**	20	**1350**	58	**85**
Lower Mill Crk.	0	796	10	12	967	65	0
Lower Mohawk	**451**	**3301**	**68**	**662**	876	**486**	5
Marten	0	3	0	0	208	0	0
McGowan	0	318	3	29	412	44	0
Mid-Mohawk	0	**1232**	18	173	303	96	0
Mohawk Forks	0	0	0	1	1032	0	1
NF Gate Crk	0	70	12	0	**2078**	0	0
Parsons	0	510	12	43	323	26	0
SF Gate Crk	0	12	2	0	556	0	0
Shotgun	0	37	2	0	412	9	0
Showcash	0	77	1	0	170	4	0
Springfield	**1098**	**2435**	**185**	**721**	880	**486**	**418**
Tom Finn	0	272	9	4	**1815**	10	**90**
Upper Mill Crk.	0	17	0	0	849	0	0
Weyhawk	0	229	11	0	**1451**	2	0
Total	1942	17403	581	3102	19322	2208	959

1) Pastures, natural grasslands, and Christmas-tree farms would be used by a variety of grassland birds; some species will use only natural grasslands and pastures, thus these habitats may be underrepresented for those species.
2) Bare or Fallow fields would be used only by species of grassland birds that use bare ground (killdeer, horned lark, and common nighthawk)
3) This cover class includes cultivated grasslands as well as other field crops such as strawberries and squash. Grassland birds would not be likely to use non-grass field crops.
4) Derived by merging NWI polygons, ponds, side channels, and alcoves from the McKenzie reach landcover map (Appendix 4, Figure 13).

Black swifts nest on moist cliffs; the only potential nesting sites within the McKenzie Basin would be near or behind waterfalls. Black swifts are extremely rare and have not been documented to nest in the McKenzie Basin; they have been documented to nest elsewhere in the Cascades. Management for this species likely falls outside what is reasonable for the Watershed Council to undertake.

Other species of concern

Eleven Species of Concern occur in multiple habitat types. The American crow, American robin, barn swallow, Brewer's blackbird, mourning dove, and violet-green swallow are common in urban areas; within urban areas they are more common in areas with low housing densities than in areas with high housing densities. The Pacific-slope flycatcher, western wood pewee, western tanager, Cooper's hawk, and cedar waxwing occur in a variety of forested habitats. The Pacific-slope flycatcher is most abundant in deciduous habitats within conifer forests, the western wood pewee is most abundant in deciduous woodlands, whereas the other species seem to be equally abundant in conifer as in deciduous forests. Because of their ubiquitous nature, we do not feel that the above species need any special management actions. These species should benefit from the suggested management actions for the other habitat types.

The McKenzie River Subasin as habitat for migrating birds

The McKenzie Basin likely provides key habitats during migration for species that also breed or winter in the McKenzie Basin. Although the same species will occur during migration as during the breeding season or during winter, it is individual birds migrating from or to more northerly areas that will use the basin during migration. Petit (2000) found that during migration, general patterns of habitat use by landbirds were similar to patterns observed during the breeding season, but that more variation existed in a birds use of habitats. Petit (2000) suggests that for landbirds, guidelines developed for conservation of migratory species during the breeding season would be useful during migration but that priority areas for conservation should include large tracts of structurally diverse forests and sites adjacent to geographic barriers such as bodies of water and mountain ridges. For shorebirds and to a lesser extent waterfowl, different habitats need to be provided during migration as compared to the breeding season. For these species habitats such as marshes, bodies of water, and fields with and without standing water are important habitats.

Very little information exists regarding species that migrate through, but do not breed or regularly winter, in Oregon. We compiled a list of species that may migrate through or occasionally winter the McKenzie Basin and described key habitats for those species (Appendix 2E). Many of these species occasionally winter in the Willamette Valley and may be found within the McKenzie Basin. Conservation actions to benefit migrating birds are the same as those suggested for Species of Concern.

Western Pond Turtle

Introduction

To facilitate conservation planning for the western pond turtle in the basin, the consulting team plotted known locations of pond turtles and developed a model of pond turtle habitat suitability for ranking pond turtle "strongholds" or refugia in McKenzie River reaches. The purpose of this model is to aid the MWC in selecting reaches that offer the greatest potential for habitat management or restoration. The model is an analytical tool in which expert opinion and information synthesized from empirical studies is formalized into an explicit set of assumptions and equations. The model is meant to facilitate conservation planning in the McKenzie watershed by permitting pond turtle distribution and habitat relationships to be considered with other objectives of stakeholders. We suggest that reaches currently occupied by pond turtles and ranked as having high habitat suitability should be the focus of conservation efforts in order to maximize the likelihood of success.

Known locations occupied by pond turtles

We are not aware of any systematic, basin-wide surveys conducted to map pond turtle distribution in the McKenzie watershed. The McKenzie-Willamette Confluence Study identified several gravel pits and wetlands occupied by pond turtles (Adamus 2000 *et al*). In addition, we have acquired anecdotal sightings of pond turtles in the watershed from the Oregon Natural Heritage Program database and Cheryl Friesen (MWC Steering Committee). All known locations have been compiled into a GIS database and mapped (Appendix 4, Figure 9). River reaches which have at least one pond turtle sighting during the last five years are assumed to be occupied by a pond turtle population for the purpose of the model.

The pond turtle habitat suitability model

This habitat component of the stronghold model has been developed for use with a spatially-explicit database of habitat attributes measured or estimated on the McKenzie River floodplain for this project. Suitability functions in this model are calibrated to distributions of input variables in this particular database. We would urge caution before using this model with other sources of data. It is not intended that model ratings should represent predictions of pond turtle spatial distribution, carrying capacity, or population viability. Such a model would require much more comprehensive population and habitat data than is presently available in the McKenzie watershed. Our model is similar to the approach of Habitat Suitability Index (HSI) models developed for the western pond turtle (Hayes 1992) and other vertebrates (Van Horne and Wiens 1991) in that it uses measurable environmental variables as inputs to estimate relative habitat quality. Our habitat model differs from other HSI models in that the output of the model is an ordinal rank of pre-determined assessment units, rather than a continuous, numeric HSI score. We selected model input factors from the list of reach descriptors (part 1) based on our literature review of previous syntheses of pond turtle habitat selection studies. We have relied most heavily on information reported in Holland (1994) and Hayes (1992).

To combine reach metrics into ratings for each of the three life requisite sub-scores (i.e., foraging score, nesting score, over-wintering score), we used addition without truncation equations (Van Horne and Wiens 1991). This function is used to represent relationships in which habitat components are completely compensatory until the optimal threshold is attained. No compensation occurs after the optimal threshold is reached. To combine life requisite sub-scores into an overall reach rating, we used a geometric mean equation (Van Horne and Wiens 1991). This function assumes that sub-scores are partially compensatory, but the reach rating is weighted most heavily by the lowest sub-score. We have selected this equation because we believe it is a useful method for ranking river reaches for conservation actions, not because we assume that the three different life requisites are compensatory.

<u>Foraging habitat</u>

Our model ranks the suitability of reaches as pond turtle foraging habitat based upon the relative reach area in side channels and lentic habitats. We assume that reaches having more channel slackwater and lentic area will have more foraging habitat available for pond turtles. We utilize two reach metrics to indicate foraging habitat suitability. The equation for rating foraging habitat suitability and descriptions of indicators are as follows:

$$FR_r = AS_r(0.5)+PS_r(0.5)$$

Where

FR= foraging rating
AS = alcove suitability score
PS = natural pond suitability score
r = reach

1. *Alcove Area* (*AA*): Total area (acres) of river alcoves in reach. Alcoves are delineated as polygons on aerial photos. The photos are then digitized and alcove area measured using a GIS.

Estimated *Alcove Area (AA)*	Suitability Score
Upper 50% of reaches ranked by AA	1.0
Lower 50% of reaches ranked by AA	0.5
Reaches with no alcove habitat	0

Aquatic features classified in Appendix I that are considered alcoves include: ALC, ALCN, and SC.

2. *Pond* Area (PA): Total area (acres) in natural, permanent intermittent ponds and constructed ponds. Ponds are delineated as polygons on aerial photos. The photos are then digitized and pond area measured using a GIS.

Estimated *Pond Area* (*PA*)	Suitability Score
Upper 50% of reaches ranked by PA	1
Lower 50% of reaches ranked by PA	0.5
Reaches with no pond habitat	0

Aquatic features classified in Appendix I that are considered ponds include: PNC PN and PO. Gravel pits and other artificial impoundments along the McKenzie also are used by pond turtles River (Andrus et al. 2000*).* However, we have not included these features as potentially suitable habitat in this model because we assume that land uses at these sites would conflict with habitat management for pond turtles.

<u>Nesting habitat</u>

Western pond turtles typically excavate nests in dry, often clay, soils (Holland 1994). Nests have been found more than 400 m from permanent water (Holland 1994). Nest sites are usually on south to southwest aspects and typically have sparse vegetation cover (Holland 1994, Rathbun, 1992). A previous habitat model for the western pond turtle utilized 11 indicators of soil texture, topography, vegetation, and disturbance to estimate nesting suitability (Hayes 1992). However, such a detailed habitat characterization is not feasible using remotely-sensed data. Instead, we have assigned nesting habitat suitability scores to several types of vegetation and land use cover classes based on assumptions we make about factors affecting the likelihood of nest success within these classes (i.e., canopy closure, frequency of soil disturbance, other human impacts). We use the following equation and land cover classification to rate foraging habitat suitability in river reaches:

$$NR_r = \frac{\sum_{i=1}^{n} (s_i at_i df_i) area_i}{area_r}$$

Where

NR = nesting rating
r = reach
i = map polygon in reach
s = nesting suitability score
at= aspect(cosine transformed)
df= distance to water score
where df=1.0 if mean distance to foraging polygons <150m, or
df=0.5 if mean distance to foraging polygons >150m
n = number of polygons in reach
$area_i$ = area (acres) in $polygon_i$
$area_r$ = area (acres) in $reach_r$

The suitability scores assigned to the land cover classes are as follows:

Class	Description	Nesting Suitability Score
CC	Clear cut	0.25
SR	Short riparian brush	0.25
G	Grassland	1.0
CG	Mixed conifer / grass	0.5
CHG	Mixed conifer / hardwood / grass	0.5
COG	Mixed conifer / oak / grass	0.75
HG	Mixed hardwood / grass	0.5
OG	Mixed oak / grass	0.75
F	Farm field	0.5
Else	All other classes in Appendix I	0.0

Over-wintering habitat

Individuals from some populations of western pond turtles move to terrestrial sites during the winter (Holland 1994). There appears to be a greater tendency for this seasonal migration among pond turtles that have summer home ranges in lotic habitats, than individuals in pond-dwelling populations (Holland 1994). Such a strategy would seem to benefit turtles occupying alcoves and side-channel habitats along the main stem of the McKenzie. Western pond turtles do not appear to be well adapted to the dynamic hydrological regime characteristic of the McKenzie River during winter high flows. Turtles at terrestrial over-wintering sites burrow in deep layers or leaf litter, thus forested sites, particularly hardwood stands, offer the most suitable over-wintering habitat (Holland 1994). We use the following equation and suitability scores to rate over-wintering habitat suitability in the McKenzie River reaches:

$$WR_r = \frac{\sum_{i=1}^{n} s_i\,(area_i)}{area_r}$$

Where

WR = over-wintering rating
r = reach
i = map polygon in reach
s = over-wintering suitability score
$area_i$ = area (acres) in $polygon_i$
$area_r$ = area (acres) in $reach_r$

The over-wintering habitat suitability scores (*s*) assigned to landscape cover classes are as follows:

Class	Description	*s*
O	Oregon white oak	1.00
H	Other hardwoods	1.00
C	Conifer	1.00
MCH	Mixed conifer / hardwood	1.00
MCG	Mixed conifer / grass	1.00
MCHG	Mixed conifer / hardwood / grass	1.00
MCO	Mixed conifer / oak	1.00
MCOG	Mixed conifer / oak / grass	1.00
MHG	Mixed hardwood / grass	1.00
MOG	Mixed oak / grass	1.00
SR	Short riparian brush	0.50
ALC	Alcove	1.00
PN	Natural pond not normally connected to the river	1.00
PNC	Natural pond normally connected to the river	0.75
Else	All other classes in McKenzie Reach Landcover Map	0.00

<u>Ranking McKenzie River reaches</u>

The stronghold potential is ranked among the 38 reaches according pond turtle distribution (i.e., occupancy) and relative habitat quality using the following equation:

$$RANK_{r0\ldots37}[SS_r = ((FR_r*0.5)+(NR_r*0.25)+(WR_r*0.25)) + T0_r]$$

Where

SR = Stronghold score
r = reach
FR = Foraging rating
NR = Nesting rating
WR = Over-wintering rating
TO = Turtle occupancy
and where, if reach is occupied then TO=2.0, else TO=0.0

<u>Comparisons between current and historic conditions</u>

To identify changes in habitat availability for pond turtles between historic and current watershed conditions, we compared habitat sub-scores based on the 2000 reach map to a 1944 map. The 1944 reach map (Appendix 4, Figure 13) was developed for the project by digitizing aerial photos and classifying landcover with the same scheme used for the 2000 reach map (see study area definition, Part 1). Comparisons were only possible on three reaches (Reaches 1-3) in the vicinity of the confluence between the Willamette and McKenzie Rivers because reach boundaries differed too widely among other reaches to permit comparisons between the two maps. Alsea-Geospatial is continuing work on the 1944 map and we anticipate the historic analysis will be completed early in 2001.

Evaluation of the model

We are not aware of any empirical studies relating pond turtle abundance or life history parameters to landscape characteristics in the McKenzie basin or Willamette Valley that could serve to as an independent data source to validate our habitat suitability model. Thus, we are unable to infer habitat preferences of pond turtles based on reach rankings of our model. In spite of this shortcoming, we maintain that the model can serve as a useful decision-making tool for identifying stronghold habitats for pond turtles. We did solicit an independent review of the model and met a panel of western pond turtle experts (i.e., Western Pond Turtle Conservation Group; 11/17/00 meeting at BLM, Eugene office) to judge whether the model meets the stated purpose. The final model version incorporates several improvements recommended during the meeting.

Findings

Experts we contacted were unaware of any systematic pond turtle inventory surveys conducted in the basin. Thus, knowledge of current pond turtle distribution is limited to anecdotal information and recent observation records. We acquired all available records from the Oregon Natural Heritage Program computerized database, the ODFW Springfield Office, the McKenzie Watershed Council's Confluence Study, and the U.S. Forest Service, Blue River District. These sources documented a total of 20 observations between the confluence with the Willamette River and Blue River Reservoir (Appendix 4, Figure 9). Holland's (1994) pond turtle range map encompasses all but two of the recent sightings. The two outlying sightings occurred at the Blue River Reservoir. It is unclear whether suitable habitat existed along Blue River before the reservoir was constructed. The two sightings at the reservoir may represent a historic population, or a recent range extension.

Our stronghold model indicates two general areas on the McKenzie floodplain where pond turtle populations coincide with relatively high habitat suitability scores: the Willamette-McKenzie confluence, and reaches in the vicinity of Camp Creek (Appendix 4, Figure 10). Suitable foraging habitat for pond turtles is rare along the McKenzie River; less than 0.5% of the water surface area in the delineated river reaches was classified capable of supporting the species (Appendix 4, Figure 9). Pond turtles also use riparian and upslope areas for nesting and over-wintering. Nesting habitat was more available throughout the delineated reaches. However, the model we used to map nesting habitat did not include some important factors that could modify habitat quality (e.g., soil characteristics, vehicle traffic patterns). If these data were available and could be incorporated into the model, we anticipate that high quality nesting habitats would actually be more limited than represented on maps in this report. Requirements for terrestrial, over-wintering habitat do not appear to be very specific. Many types of closed-canopy woodlands and forests may provide suitable cover. However, traffic-related mortality may be an important factor limiting the suitability at some locations.

Availability of pond turtle foraging habitat in the confluence area did not differ between 1944 and 2000 (Table 2-12). Nesting habitat increased 14%, and over-wintering habitat decreased 26% from 1944 to 2000. A graphical comparison of the current and historic maps indicates that these trends are largely due to conversion of riverine forests to agricultural fields. We urge caution in interpreting the comparison of nesting habitat scores between the two periods. The forest openings created by agricultural fields may provide greater availability of potential nest sites, but effects of all farming practices (e.g., plowing and cultivation) are not accounted for in suitability scores.

Based on sighting records, results of habitat modeling, and a graphical examination of road densities, the confluence of the McKenzie and Willamette Rivers, and Reaches 10-12 seem to offer the greatest opportunities for pond turtle habitat management and population monitoring. We assume the sighting records acquired for this assessment represents a very incomplete picture of pond turtle distribution in the lower McKenzie watershed. We suggest that an important initial step in conservation planning for the species is a more systematic population survey for pond turtles in the lower McKenzie and Mohawk watersheds to identify strongholds. Most of the known pond turtle locations and highest quality are on, or surrounded by private lands. Thus, we recommend that turtle conservation programs promote landowner awareness and education about pond turtles. These efforts may facilitate collaborative monitoring and habitat management programs in the future. Finally, experts we interviewed believe traffic-related mortality may be a significant limiting factor to pond turtle populations, particularly in metropolitan areas. One potential method to address this issue is to track migrations of female turtles from aquatic sites to nesting locations using radio-telemetry. Compared to most other reptile species, adult turtles are relatively easy capture and monitor using telemetry. Conservation efforts could then focus actions at specific road crossings where significant mortality occurs during dispersal and migration.

Table 2-12. Comparison of western pond turtle habitat availability (ac) estimated from aerial photos made in 19944 and 2000. Reaches 1-3 are located in the vicinity of the confluence between the McKenzie and Willamette Rivers.

		Habitat Availability (ac)	
		1944	2000
Foraging	Reach[1]		
	1	32	53
	2	34	25
	3	29	15
	Total	95	93
Nesting	1	1548	1792
	2	1042	1326
	3	1157	1253
	Total	3747	4371
Over-wintering	1	1082	891
	2	765	547
	3	1197	514
	Total	3044	1952

[1]Reach 3 combines reaches 0 and 3 in the 2000 McKenzie Reach Landcover Map.

Future Trends: Priority Vegetation Types and Wildlife

Our assessment of priority terrestrial vegetation types and wildlife habitats is largely based on existing field data and remote-sensing methods that provide only a broad characterization of the lower watershed. Forecasting future distributions of plant and animal communities entails even greater uncertainty because of the difficulty of predicting changing land use practices in the McKenzie River subbasin. However, conserving biodiversity in the Basin depends on the ability of land managers and urban planners to understand the consequences of their decisions may have on ecosystems. Until more empirically-based land use projections are available, we offer the following perspectives on future plant and wildlife communities trends based on our literature review and qualitative analyses.

The landcover maps prepared for this report indicate that wetlands and ponds are concentrated near the McKenzie-Willamette confluence, the lower Mohawk watershed, and along the McKenzie floodplain between the confluences of Mohawk River and Camp Creek. Our literature review suggests that a significant reduction in wetland plant communities and associated wildlife habitat components has already occurred. The principle factors causing declines in wetland distribution have been agricultural practices, river channelization, and residential development on floodplains. Riparian hardwood communities (e.g., cottonwood and Oregon ash) and shrub communities (e.g., willows, red-osier dogwood) have been similarly affected by these land uses. It is our opinion that increasing urbanization in the Eugene-Springfield metropolitan area poses the greatest future threat to wetlands, western pond turtles, and several avian species of concern (Table 2-10) during the next decade. Population growth will inevitably increase pressure to expand the urban growth boundary along the McKenzie River. Although agricultural practices have altered plant communities and flood patterns in wetlands and ponds, many of these areas probably could be restored to highly suitable habitats for several species at risk. For this to happen, willing landowners, in conjunction with incentives, will be needed. No similar restoration opportunities exist once wetlands areas are developed for commercial and residential purposes.

The distribution of Oregon white oak woodlands and savanna plant communities has been reduced in the lower watershed by multiple, cumulative impacts. Major contributing factors are land conversion to agriculture or residential uses, forestry practices that favor Douglas-fir, and cessation of historic fire setting by the Kalypuya. Without conservation measures, we anticipate that oak woodlands in the metropolitan area will continue to be lost to the same development pressures we predict will reduce wetlands. However, extensive areas of mixed oak-conifer forest remain in the Coburg Hills and other uplands. Recent papers (Shelly 1997, Thompson 1997) have described the potential for expanding oak wood products market. Although market forecasts are mixed, some small woodland owners in the McKenzie Basin wishing to balance commodity production with biodiversity goals or wildlife habitat management may be encouraged to experiment with oak silviculture. Forest certification organizations active in the Pacific Northwest (e.g., Forest Stewardship Council) are also promoting multi-species silvicultural systems that may influence some owners to actively manage

Oregon white oak on their woodlands. In the absence of active management or conservation efforts, we predict that Oregon white oaks will become increasingly rare in the lower McKenzie Basin as mixed oak-conifer stands are lost to development or eventually become entirely dominated by Douglas-fir or grand fir.

We identified more than 70 species of birds known to occur in the McKenzie Basin for which there is evidence of declining abundance or an increasing degree of population fragmentation. Some species have somewhat more general habitat requirements and are at less risk, at least in the short term, than species with highly specific habitat requirements. Examples of such "generalist" species include: violet-green swallows, Cooper's hawk, American crow, among others. Other species have been extirpated from the Basin or undergone such serious population declines that major recovery efforts (probably beyond the scope of the McKenzie Watershed Council) would be necessary to secure their future viability. These species include: Lewis' woodpecker, yellow-billed cuckoo, and burrowing owls. Our analysis leads us to conclude that the next decade may be particularly critical for many of the avian species of concern in our report. Grassland and woodland species in this category are the western meadowlark, horned lark, vesper sparrow, grasshopper sparrow, western bluebird, and white-breasted nuthatch. Our research and professional experience leads us to conclude that expanding urbanization will place these species at critical risk. However, conservation programs and habitat management on agricultural lands could greatly improve the outlook for these species. Riparian- and wetland-associated bird populations in the lower Basin we believe to be at a similar threshold during the next ten years include: the northern pintail, harlequin duck, bald eagle, and willow flycatcher.

Finally, western pond turtle populations in the lower McKenzie Basin are threatened by the loss of wetlands in the metropolitan area, predation by exotic fish and bullfrogs, and soil disturbing activities on agricultural lands that can destroy nests. The future viability of pond turtles depends on the extent to which landowners and governments consider habitat requirements of the species in land management plans. The McKenzie Watershed Council should be encouraged to continue its outreach and education programs as one avenue for raising awareness of the pond turtle issue.

Recommended Conservation Actions for Wildlife Species and Habitats of Concern

Prioritization

Based on objectives defined by the Steering Committee and findings of our research, we conclude that some ecosystem components are critically in need of conservation planning if they are to be maintained in the lower McKenzie Basin. Populations most at risk include the willow flycatcher, yellow-breasted chat, as well as other bird species associated with lowland riparian habitats. Appendix 2C lists bird species that may be at the brink of extirpation in the Willamette Valley and western Cascade lowlands. Among the priority vegetation types we mapped, savannas and native grasslands no longer exist in the McKenzie Watershed as functional, fire-maintained ecosystems. Alternative agriculture systems patterned after native valley ecosystems may offer a solution to managing biodiversity while meeting other objectives of landowners. We recommend that the Watershed Council further facilitate these efforts in the McKenzie Basin to the extent appropriate within the mission of the Council.

Restoration

Ecological restoration usually involves the reconstruction of native or semi-natural ecosystems on degraded lands or the reintroduction of native species (Miller et al. 1995). Restoration opportunities exist in the lower McKenzie Basin for almost all of the wildlife habitats and priority vegetation types we assessed. Some illustrative examples of restoration projects include:

- The Eugene District of the BLM has already initiated an oak woodland restoration program in the McKenzie Resource Area (Chiller and Vesely 2000). However, higher quality stands exist on neighboring, private woodlands. The Watershed Council could facilitate oak woodland restoration efforts by encouraging active oak management on neighboring woodlands. Public land managers and private small woodland owners are likely to achieve greater success in restoring large woodland patches and reducing woodland fragmentation by working across property boundaries rather than by conducting separate restoration efforts. Potential actions by the Watershed Council could include arranging free or low-cost woodland restoration planning to private landowners by professional foresters with experience in oak silviculture and knowledge of resource conservation incentive programs.

- No native grassland-oak savannas remain in the McKenzie Basin. Wildfires to maintain savannahs are not likely to be permitted by stakeholders in the lower watershed. Researchers at OSU, Oregon Department of Fish and Wildlife, and other organizations are identifying agro-forestry methods that may lead to development of agricultural landscapes that function similarly to native savannas for some wildlife species. The Watershed Council could encourage landowners to try new agricultural systems by identifying resources (e.g., educational, professional consultation, incentives) that reduce the economic uncertainty associated with new approaches to farming and ranching.

- Western pond turtles have been identified by ODFW as a species in critical need of conservation planning. Our analysis identified the Willamette-McKenzie confluence as having the greatest potential for establishing strongholds to ensure viability of the species in the lower Basin. The Watershed Council could facilitate habitat restoration efforts in the confluence area by fostering partnerships between conservation biologists and sand-and-gravel operators. Flooded gravel pits are used by turtles, but nesting habitat suitability would likely be increased with mitigation actions (Andrus et al. 2000).

Conservation/ Protection

Conservation approaches to managing wildlife and their habitats include a wide range of actions designed to ensure the persistence of vertebrate populations and functioning environments capable of supporting them. Our assessment has identified known locations of patches of priority habitats and some vertebrate species of concern. The Watershed Council may have a variety of options within its scope to secure critical components of biodiversity. We propose the following actions for the Watershed Council to consider:

- Encourage Lane County and city governments to consider managing for native ecosystems in public parks and greenspaces. The Watershed Council could foster partnerships between park managers, ecologists, and landscape designers to seek innovative approaches for preserving large diameter oaks, wetlands, and riverine woodlands while improving recreation and educational opportunities in parks.

- Contact landowners that likely possess areas containing oak woodlands, wetlands, and pond turtle strongholds located through this assessment. Provide educational programs for owners of areas with habitats at risk. Educational programs should emphasize the ecological significance of their land and teach known methods to maintain crucial elements of biodiversity.

- Sponsor a systematic survey of western pond turtles in the lower McKenzie Basin. Identify key aquatic and nesting habitats used by each population. Determine specific threats to the viability of each population.

- Several species of birds associated with key vegetation types in the McKenzie Watershed are in need of conservation efforts (see Table B2). We encourage the Watershed Council to take an active role in preserving habitats that are important for those species.

Monitoring

Monitoring is used to track changes in populations or distributions of key habitats or species and to determine if conservation actions are accomplishing their intended goals. Monitoring is critical to the long-term success of a conservation program because results of monitoring assist in determining if changes in conservation actions are needed. We propose the following actions for the Watershed Council to consider:

- Repeat the systematic survey of western pond turtles (recommend above) in the lower McKenzie Basin at regular time intervals to monitor changes in populations and distribution of this species.

- For all on-the-ground conservation projects, develop a monitoring program to track changes in the population of the intended species to benefit from the conservation actions.

Conservation Partnerships and Educational Opportunities

Research conducted for this assessment revealed several other on-going conservation and ecological monitoring efforts and educational opportunities that are pertinent to the McKenzie Watershed. We recommend that the McKenzie Watershed Council explore the feasibility of partnerships with groups sharing goals similar to those of the Council. Brief descriptions of existing conservation efforts and educational opportunities that are ongoing, completed, or likely to be active in the future are listed below. In addition, the Watershed Council would benefit from the formation of a McKenzie wildlife working group that could act to educate and facilitate cooperation so that the recommended actions can be accomplished.

Defenders of Wildlife / Oregon Biodiversity Project*:* A collaborative effort involving dozens of public and private partners to develop a statewide strategy for conserving Oregon's biological diversity. The program has designated a region near Vida, Oregon as a Conservation Opportunity Area for the West Cascades Ecoregion (Oregon Biodiversity Project 1998).

Ducks Unlimited: The mission of Ducks Unlimited is to fulfill the annual life cycle needs of North American waterfowl by protecting, enhancing, restoring and managing important wetlands and associated uplands. The Western Regional Office of Ducks Unlimited, Inc. in the Pacific Flyway, has restored or enhanced more than 400,000 acres of wetlands and associated uplands. Technical assistance has been provided on 618,000 acres of habitat. The Geographic Information Systems staff has mapped more than 91 million acres. Easements and acquisition agreements protect more than 29,000 acres of habitat. DU has completed 93 projects totaling more than 47,000 acres in the Pacific Northwest area. Over the next 5 years they plan to restore over 45,000 additional acres of wetlands and uplands throughout Oregon and Washington and marshes along The Great Salt Lake in Utah. Information is available at http://www.ducks.org/

North American Waterfowl Management Plan: This plan is an international action plan to conserve migratory waterfowl throughout North America. The goal of the plan is to return waterfowl populations to their 1970's levels by conserving wetland and upland habitats. The Plan is a partnership of federal, provincial/state and municipal governments, non-governmental organizations, private companies and many individuals. Plan projects are international in scope, but implemented at regional levels. Information regarding the plan is available at http://www.nawmp.ca/

Oak Communities Group: An *ad hoc* group has been recently formed by landowners, biologists, and agency representatives interested in conservation of oak habitats. The group includes members from the entire Pacific Northwest, but membership is largely dominated by Willamette Valley biologists, woodland managers, and private land-owners. The group has quarterly meetings at different locations at which presentations are given regarding management, conservation, and ecology of oak woodlands and savannas. In addition, subgroups have been formed to further investigate opportunities for research and restoration, funding, education, resources for private landowners, etc. For more information, contact Jane Kertis, Siuslaw National Forest, (541) 750-7000,jkertis@fs.fed.us.

McKenzie River Trust: A local, nonprofit land trust that has been active in the McKenzie watershed since 1989. Their mission is to protect special lands, utilizing acquisition of full titles or easements via purchase and donation of lands. They received $500,000 outright and $500,000 in the form of a matching grant to acquire properties that will protect water quality and fish and wildlife habitat. They developed a property evaluation form which is used to aid in establishing priorities for land acquisition when implementing EWEB grants.

Partners in Flight Conservation Plans: Partners In Flight was launched in 1990 in response to growing concerns about declines in the populations of many land bird species, and in order to emphasize the conservation of birds not covered by existing conservation initiatives. The initial focus was on species that breed in the North America and winter in Central and South America, but the focus has spread to include most landbirds and other species requiring terrestrial habitats. Partners In Flight is a cooperative effort involving partnerships among federal, state and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals. Currently partners include 16 federal agencies, 40 nongovernmental organizations (NGOs), over 60 state and provincial fish and wildlife agencies, numerous universities, and the forest industry, and the list is growing daily. Partner's in Flight has developed a series of scientifically based landbird conservation plans that are the foundation for PIF's long-term strategy for bird conservation. Two plans exist for regions that overlap with the McKenzie Basin: 1) Conservation Strategy for Landbirds in Lowlands and Valleys of Western Oregon and Washington (Altman 2000) and 2) Conservation Strategy for Landbirds in conifer forests of Western Oregon and Washington (Altman 1999). These plans contain background information about a variety of habitats and the birds that use them as well as detailed conservation recommendations. The plans are available at http://community.gorge.net/natres/pif.html.

Western Pond Turtle Conservation Group: An *ad hoc* group of biologists and agency representatives formed for the purpose of developing a regional approach to pond turtle conservation. Members of this group reviewed the pond turtle stronghold model developed by Pacific Wildlife Research for this assessment. Several group members stated that the modeling approach could be adapted to pond turtle assessments beyond the McKenzie Basin. The present Coordinator is Robert Horn, Umpqua National Forest. Cheryl Friesen, a member of the McKenzie Watershed Council's technical advisory committee, is a member of the group.

Workshops for private land-owners interested in creating or maintaining habitat for grassland birds: The Oregon Department of Fish and Wildlife conducted a series of workshops for industrial and non-industrial private landowners who were interested in learning techniques to providing habitat for grassland birds. Funding and interest permitted, future workshops may be planned. For more information, contact the Oregon Department of Fish and Wildlife, Watershed District Office, Adair, (541) 757-4186.

USGS Patuxent Wildlife Research Center: This is a US Geological Survey Research Program focused on biodiversity inventory and monitoring. The North American Breeding Bird Survey (BBS) (http://www.mp2-pwrc.usgs.gov/bbs/index.htm) and the North American Amphibian Monitoring Program (NAAMP) (http://www.im.nbs.gov/amphibs.html) are two of their programs. The BBS includes sampling sites in, and surrounding the McKenzie Basin. We found data from this program available on the World Wide Web to be very useful for measuring bird population trends. The NAAMP does not presently have a monitoring site in the McKenzie Basin. However, we suggest that the Watershed Council consider sponsoring a NAAMP sampling site to collect data that would permit amphibian population trend studies in the McKenzie Basin.

Annual Bald Eagle Nest Survey: An extensive survey effort conducted across Oregon by Frank B. Isaacs and Robert G. Anthony of the Oregon Cooperative Fish and Wildlife Research Unit. Support for this monitoring program will ensure that bald eagle population data will be continued to be collected in the McKenzie Basin.

Part 3: Synthesis and restoration

Detailed Table of Contents

Part III: Synthesis and restoration

Characterizing fish habitat

Background

In this section we present a method for scoring fish habitat quality within reaches of the McKenzie River for year 2000 or year 1944 conditions using information obtained from aerial photographs and from limited field surveys (2000 only). The objective is to identify reaches (or sides of reaches) that currently have high quality fish habitat or those that had high quality in 1944. Scoring fish habitat quality can help in identifying areas that are high priority for protection or restoration.

The method was developed for the study area beginning at the old McKenzie River confluence, to the current McKenzie River confluence in the Willamette River, and then upstream into the McKenzie River about 51 miles to the Quartz Creek confluence. The 1944 aerial photographs extend only to Leaburg Lake so upstream information (Leaburg Lake to Quartz Creek) is not available for that period.

In this section we present results of modeling for juvenile chinook salmon, the fish species that was chosen to be the focus for habitat protection and restoration in this study.

Method

Characterizing habitat quality when more than one variable is involved can be complicated because parameters may not be in common units and some parameters may contribute more than others to overall habitat quality. One way to address this problem is by (1) transforming each parameter or variable to a common scale, (2) assigning a weighting to each variable, and then, (3) adding the weighted scores for all of the variables.

1. The first step is often referred as standardizing the values of a variable. In this process the reach with the highest value (expressed as area, length, or number per 1000 feet of thalweg length) is assigned a score of 1 and the reach with the lowest value, a score of 0. All other reaches are assigned a score that falls between 1 and 0, in proportion to their place in the original distribution of values. The equation for this calculation is:

$$\text{STANDARDIZED SCORE} = (X-X_{MIN}) / (X_{MAX}-X_{MIN})$$

The table below provides an example of variable values and their standardized scores.

Reach & side	Alcove area (ac. per 1000 ft of river)	Standardized score
2N	0.84	0.52
2S	0.17	0.05
3N	0.72	0.44
3S	0.31	0.15
4N	0.20	0.07
4S	1.52	1.00
5N	0.10	0.00

2. In the next step, weights are assigned to each of the variables. Here, choices are made concerning which variables are relatively more important than others in their contribution to overall fish habitat quality. For example, the area of alcoves may be considered a strong benefit to fish and be assigned a weighting of +3 while the area of riparian forest greater than 40 years old may be considered a less important factor and assigned a weight of +1. Variables that are indicators of harm to fish habitat quality are assigned a negative weighting. For example, riprapped banks may be considered a negative influence on fish habitat quality and be assigned a weighting of –1.

3. The third step involves a simple addition of the parameter values that have been multiplied by their weighting. The sum of weighted values are then standardized, with final scores that range from 0 to 1, as illustrated below:

	Side channel area		Length of riprap		Alcove area		
Reach & side	A Stand-ardized Score	B Weight-ing	C Standard-ized Score	D Weight-ing	E Standard-ized Score	F Weight-Ing	A*B+C*D+E*F Sum of weighted Scores (standardized values are in parenthesis)
2N	1.00	2	0.00	-1	0.52	3	3.56 (1.00)
2S	0.31	2	0.00	-1	0.05	3	0.77 (0.39)
3N	0.00	2	0.23	-1	0.44	3	1.09 (0.46)
3S	0.33	2	0.23	-1	0.15	3	1.34 (0.51)
4N	0.02	2	0.79	-1	0.07	3	-0.54 (0.10)
4S	0.00	2	0.79	-1	1.00	3	1.21 (0.48)
5N	0.00	2	1.00	-1	0.00	3	-1.00 (0.00)

The sums of weighted scores are themselves standardized to end up with final fish scores that range from 0 to 1. In the above example, a combination of the three habitat variables indicated that reach 2N had the "best" habitat quality score among the 7 reaches. Reaches with the "worse" habitat quality score were 4N and 5N.

This method of enumerating habitat quality is highly flexible; variables can be added or subtracted as desired, and weightings can be changed as your understanding changes about the relative contribution of each variable to overall fish habitat quality.

McKenzie River main channel juvenile salmon habitat

We have chosen the variables to include and their weightings for evaluating habitat quality in the McKenzie River for juvenile chinook salmon. These fish utilize a wide variety of habitat features during the 6 to 18 months that they rear in the river. This selection of variables and their weightings also generally applies to rainbow trout and cutthroat trout, but not to mountain whitefish which rear almost exclusively in the main channel. For mountain whitefish and native fishes that are not salmonids, a subset of the model parameters and custom weightings should be selected, depending on specific habitat needs of the fish.

A computer program accessible through the internet can be used to evaluate juvenile chinook salmon habitat and explore alternative evaluations:

www.upstreamconnection.com/client/waterwork/mckenzie.cfm

Thirteen variables were included in the model for juvenile chinook salmon, as listed in Table 3-1. Each variable is discussed below:

Table 3-1. Variables used in the juvenile chinook salmon habitat model.

Variable	Description
Positive indicators:	
Alcove area	Acres of alcoves per 1000 feet of river
Side channel area	Acres of side channels per 1000 feet of river
Natural ponds area	Acres of natural ponds (within a 1000-foot lateral distance from the river) per 1000 feet of river
Connected gravel pit area	Acres of gravel pit pond (within a 1000-foot lateral distance from the river) per 1000 feet of river. Includes only those that have year-round connection with the main channel
Island area	Acres of island per 1000 feet of river
Main channel area	Acres of main channel per 1000 feet of river
Rock barbs length	1000 feet of riverbank with rock bars per 1000 feet of river
Riffle length	1000 feet of riffle length per 1000 feet of river
Bare substrate area	Areas of bare substrate next to the river per 1000 feet of river.
Older trees length	Acres of trees greater than 40 years old that grow within 500 feet of the river per 1000 feet of river
Negative indicators:	
Unconnected gravel pit area	Acres of gravel pit pond (within a 1000-foot lateral distance from the river) per 1000 feet of river. Includes only those that are isolated from the main channel except during higher flows
Riprap length	1000 feet of riprapped bank per 1000 feet of river
Riverfront house density	Number of houses (up to 500' from river) per 1000 feet of river

1. Alcove area was included as a variable because these sites are used by juvenile chinook and many other native fish for refuge and feeding.

2. Side channel area was added to the model because of the feeding and refuge habitat it provides. Side channels are usually shallower with lower velocity than the main channel and are therefore more suitable for supporting a large population of aquatic insects. Also, side channel are often more sinuous than the main channel

and comprise a variety of habitat features, including complex edges and eddies (Hardin-Davis et al. 1990, Richards et al. 1992, Everest and Chapman 1972.)

3. Natural pond area was included as a variable because the ponds offer low-velocity rearing habitat that is next to the main channel that chinook and other salmonids use at various times of the years (Swales and Levings 1989). If these ponds do not have non-native fish (e.g., bass), fish benefit by being separated from predatory fish in the main channel. Similarly, gravel pit ponds that have at least seasonal connection to the main channel were considered good habitat for fish. The deep water at pits and lack of flowing water are particularly attractive to young salmon when flows are high, especially during the winter (Taylor 1988). Chinook salmon have been known to survive in gravel pit ponds for several years when trapped. Their growth rate is high in gravel pit ponds (probably because of ample food) and they are known to attain a length of 12 inches after two years (Bayley and Baker 2000).

4. Island area was also included in the modeling effort since islands increase the wetted margin of the river and provide a more diverse set of microhabitats than does a single channel. Often, islands are transient with sediment deposition and erosion occurring in close proximity. As islands are transformed or dissected during high flows, off-channel features can develop that are favorable habitat for fish.

5. We also included main channel area as a variable under the assumption that, where a channel spreads out, a greater variety of habitat types develop. A narrow channel is often a result of bedrock constriction or human constraints on channel meandering.

6. Length of river bank with rock barbs was also included in the model. Rock barbs are constructed of large, angular rock and extend perpendicularly from the bank for a distance of 20 to 30 feet. Recent fish sampling along the McKenzie River downstream of the Hwy I-5 Bridge indicates that juvenile chinook and large trout use barbs more than natural or conventional riprapped banks (Andrus et al. 2000). No rock barbs existed in 1944.

7. Riffle length was considered a positive indicator of higher quality fish habitat. For much of the lower McKenzie River riffles occur at the downstream end of large gravel deposits in the channel. Multiple channels often form at these locations and provide a wide range of habitat types for both young and adult fish. Since riffles were identified in the field, there is no data on this variable for 1944 conditions.

8. Bare substrate was also considered to be an indicator of higher quality habitat. Much of the McKenzie River channel has a coarse cobble substrate, but substrate size is more diverse at areas with bare substrate. Seining of the McKenzie River in the spring and early summer (Jeff Ziller, ODFW, personal communication) indicates that young chinook salmon congregate in areas with bare substrate, especially where diverse velocity patterns occur.

9. The presence of older trees (> 40 years) near the river was included in the model because these trees are more capable than younger trees of influencing the river by their leaves, shading, and their wood volume, if they happen to topple into the river. When growing at the very edge of the river, their large root masses of older trees provide a diverse edge effect that allows fish to find pockets of low-velocity water adjacent to fast water for effective feeding.

Three variables considered to have negative influence on habitat and were included in the juvenile chinook model. The weighted scores of these variables are negative so their values reduce the total fish score.

1. Riprapped banks are usually avoided by most fish, especially during higher flows (Knudsen and Dilley 1987). Also, riprap often results in channel narrowing as the river shifts flow towards the riprapped bank.

2. Gravel pits that flood during high water but otherwise have no connection with the river were considered a negative influence of fish. Fish can be trapped within these gravel pits, thereby disrupting their normal migration patterns. These gravel pits usually contain largemouth bass that predate on native fish.

3. Riverfront housing development was considered a negative influence on fish habitat. Trees growing between houses and the river are often removed to create better views of the river, therefore eliminating a source of fine detritus, large wood, and shading to the river.

Standardized scores for each of the 13 variables are displayed by reach and side of river in an upstream order and also in order of decreasing magnitude within Appendix 3 (Figures 1-13).

Positive weighting factors (1, 2 or 3) were assigned to variables considered a positive influence on fish habitat quality and negative weighting factors (–1, -2, or –3) were assigned to variables considered a negative influence (Table 3-2).

Table 3-2. Weighting factors assigned to positive and negative influences on juvenile chinook habitat quality.

Variable	Weighting
Positive indicators:	
Alcove area	+3
Side channel area	+3
Natural ponds area	+3
Connected gravel pit area	+3
Island area	+2
Main channel area	+2
Rock barbs length	+2
Riffle length	+2
Bare substrate area	+2
Older trees length	+1
Negative indicators:	
Unconnected gravel pit area	-1
Riprap length	-1
Riverfront house density	-1

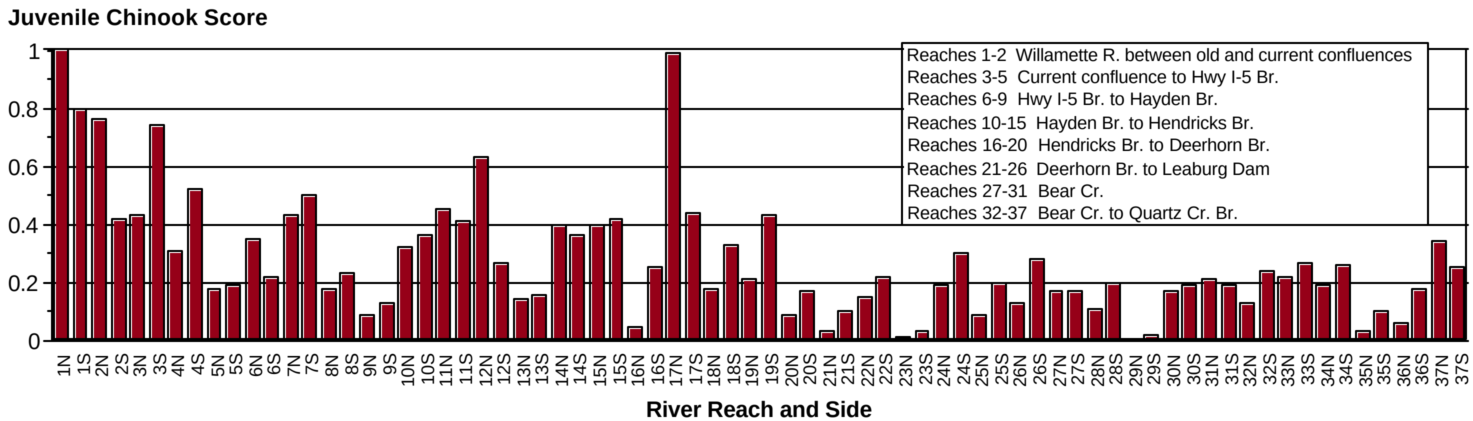
We developed an interactive computer program that allows users of this model to select parameters and their weights. The model displays graphs of habitat scores, the raw data, and displays aerial photographs of each reach. Access to the model is available for use on the internet at:

http://www.upstreamconnection.com/client/waterwork/mckenzie.cfm.

The model also allows the user to display the pond turtle index (see wildlife section) and develop a combined score of juvenile salmon and pond turtle habitat.

The standardized fish habitat scores calculated using these weightings are displayed in Figure 3-1. The modeling indicates that the north side of reach #17 has the greatest juvenile salmon habitat quality. This reach encompasses McNutt Island. The two most downstream reaches that are located in the Willamette River between the old and current McKenzie River confluences also have high quality habitat. Habitat quality is above normal in a number of reaches between Hayden Bridge and Hendricks Bridge (reaches #10 to #15) The upper one-half of the study area has some of the lowest habitat quality values. A detailed summary of 16 main channel reaches (by side of river) that currently have the highest fish habitat scores is found in Table 3-2a.

A similar comparison using reach rather than side of reach as the unit of analysis is displayed in Figure 3-1a and Table 3-2b. The 10 reaches with the best habitat include those in Table 3-2a plus reach #10.



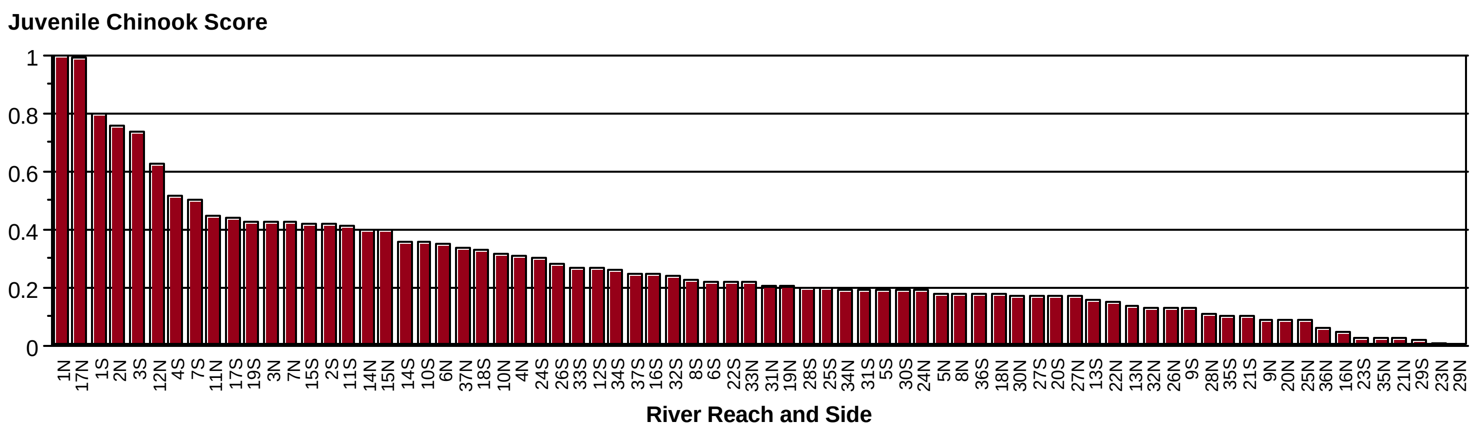


Figure 3-1. Juvenile salmon chinook habitat in year 2000 by reach and by side of reach for parameters listed in Table 3-1 and weightings listed in Table 3-2.

Table 3-2a. Reaches (by side) that currently have high fish habitat scores and would be the focus for protection and minor enhancements. Presented in order of decreasing fish habitat score.

Order	Reach	Positive factors	Limiting factors
1	1N	Many alcoves, side channels, ponds, and islands. Flood-prone area not suitable for housing development. Some older hardwoods along bank.	Old McKenzie channel has no summer flow.
2	17N	Many alcoves, side channels, and ponds. Split channel that includes McNutt Island.	Island vegetated mostly by grass. Segment of outer river bank occupied by houses. Some riprap.
3	1S	Many alcoves, side channels, ponds, and islands. Flood-prone area not suitable for housing development. Some older hardwoods along bank.	Includes proposed gravel extraction operation (set back about ¼ mile from main channel).
4	2N	Many alcoves, side channels, ponds, and islands. Flood-prone area not suitable for housing development.	Old McKenzie channel has no summer flow.
5	12N	Many side channels and islands. Some ponds. Portions are flood-prone and not suitable for housing development	Segment of outer river bank occupied by houses.
6	4S	A number of side channels, alcoves, and bare gravel	Extensive riprap and gravel pits behind berm
7	7S	Large area in side channel, island, and alcoves.	Extensive riprap and housing along one portion. Further urban encroachment.
8	11N	Meander area as indexed by alcoves, ponds, wide channel, and exposed substrate.	
9	17S	Side channels and ponds. Across river from the highest quality site.	A few houses in flood-prone areas.
10	19S	Includes 2 large islands (Kaldor and Rodman), side channels, and some older conifers along bank.	Segment of houses along major side channel.
11	3N	Side channels and islands	Future gravel extraction area
12	7N	Meander area as indexed by alcoves, islands, wide channel, exposed substrate.	
13	15S	Tight bend in river creates extensive meandering and side channels.	River front home located precariously in meander area. Landowner recently opened side channel at base of bend which could cause river to abandon current main channel.
14	2S	Alcoves, side channels, ponds, and islands. County ownership of high-quality segment. Gravel extraction company wildlife set-aside for another high-quality segment.	Some houses along segments of outer river bank and Confluence Island channel.
15	11S	Extensive flood-prone plain with side channels, islands, and Cedar Creek confluence. Older hardwoods.	Industrial settling ponds located within flood plain.
16	14N	Old gravel pit complex now connected to main channel.	Some riprap. Salmon bypass side channel for Walterville canal needs to be maintained.

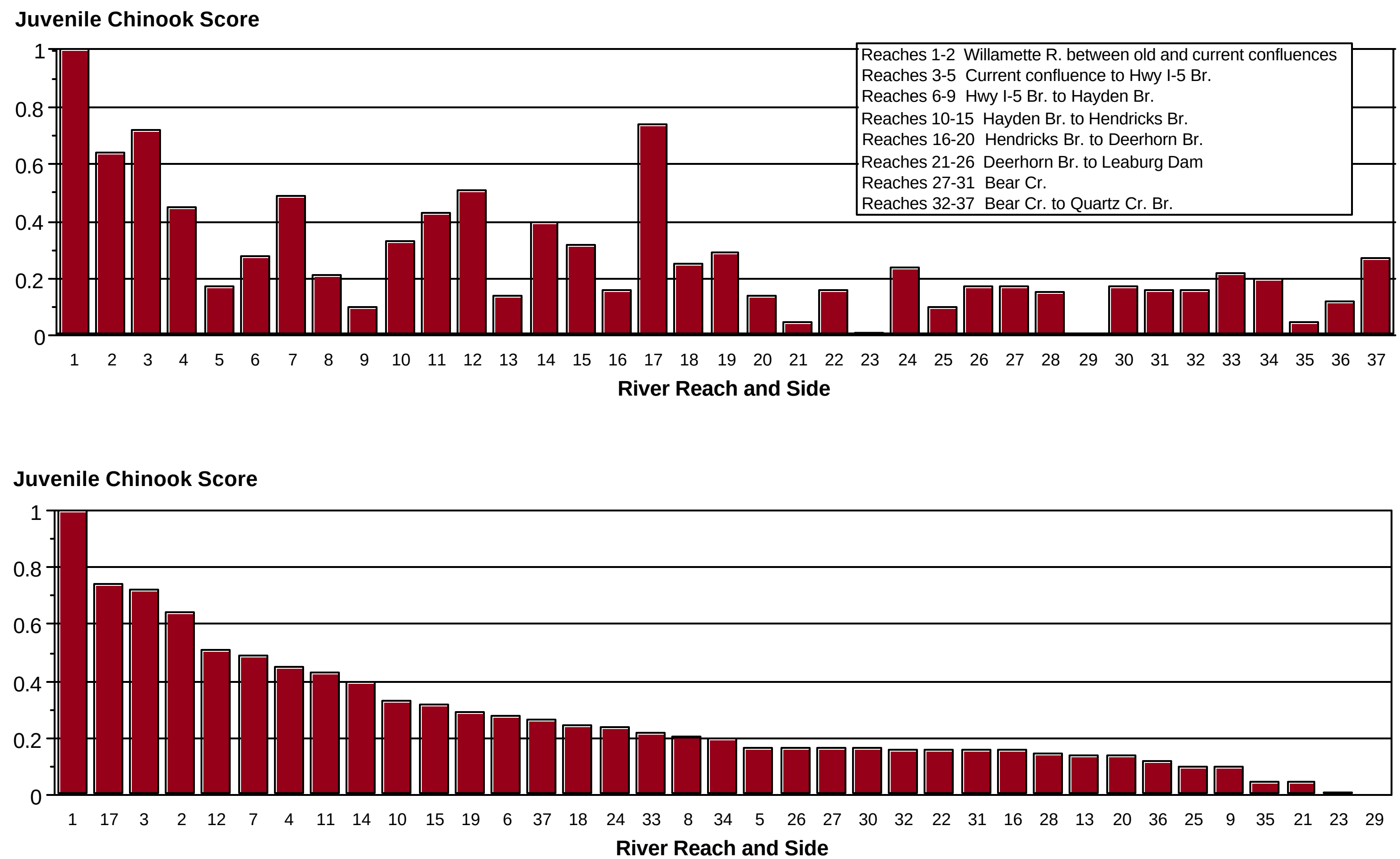


Figure 3-1a. Juvenile salmon chinook habitat in year 2000 by reach for parameters listed in Table 3-1 and weightings listed in Table 3-2.

Table 3-2b. Reaches that currently have high fish habitat scores and would be the focus for protection and enhancement. Presented in order of decreasing fish habitat score.

Order	Reach
1	1
2	17
3	3
4	2
5	12
6	7
7	4
8	11
9	14
10	10

Combining juvenile salmon habitat and pond turtle habitat scores

Decisions on habitat protection and enhancement rarely hinge on maximizing habitat for a single species. Therefore, we offer an example of how habitat quality rating for a fish species can be combined with that for a wildlife species to obtain a combined habitat quality rating.

We used the pond turtle habitat suitability scores derived by the pond turtle model, standardized the scores (Figure 3-2), and combined them with the standardized juvenile chinook habitat scores (Figure 3-1a). The two scores were summed with equal weighting assigned to the turtle scores and to the fish scores. The composite chinook/turtle habitat score was highest in the two most downstream reaches (reaches 1,2) and an in the reach that encompasses McNutt Island (reach 17) (Figure 3-3). High habitat quality was concentrated in reaches 10-12 at Springfield, reaches 6-10 downstream of Springfield, and reaches 14-15 upstream of Springfield.

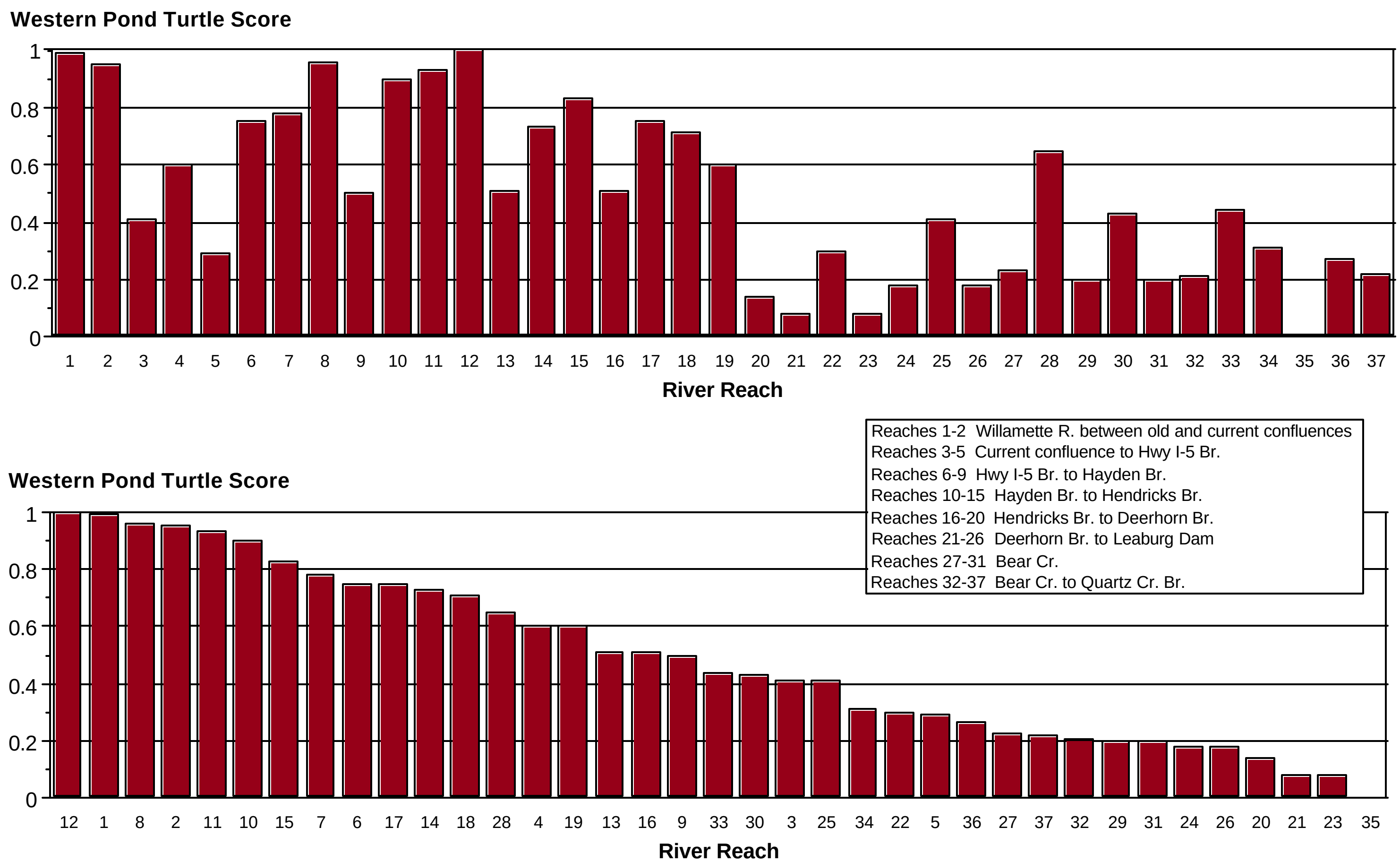


Figure 3-2. Western pond turtle habitat in year 2000 by reach.

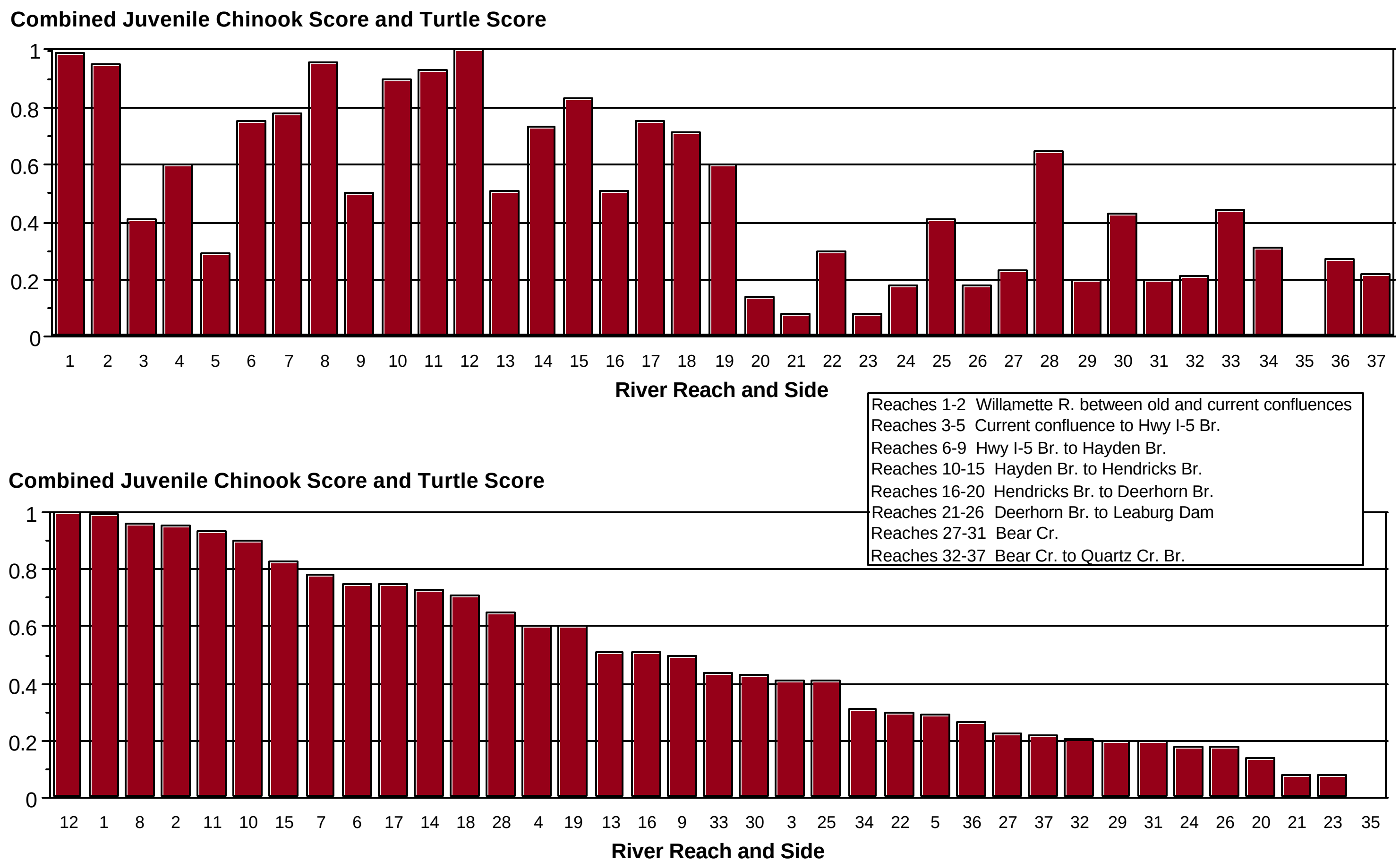


Figure 3-3. Combined juvenile chinook salmon and western pond turtle habitat in year 2000 by reach using a 1:1 weighting for chinook and turtles scores.

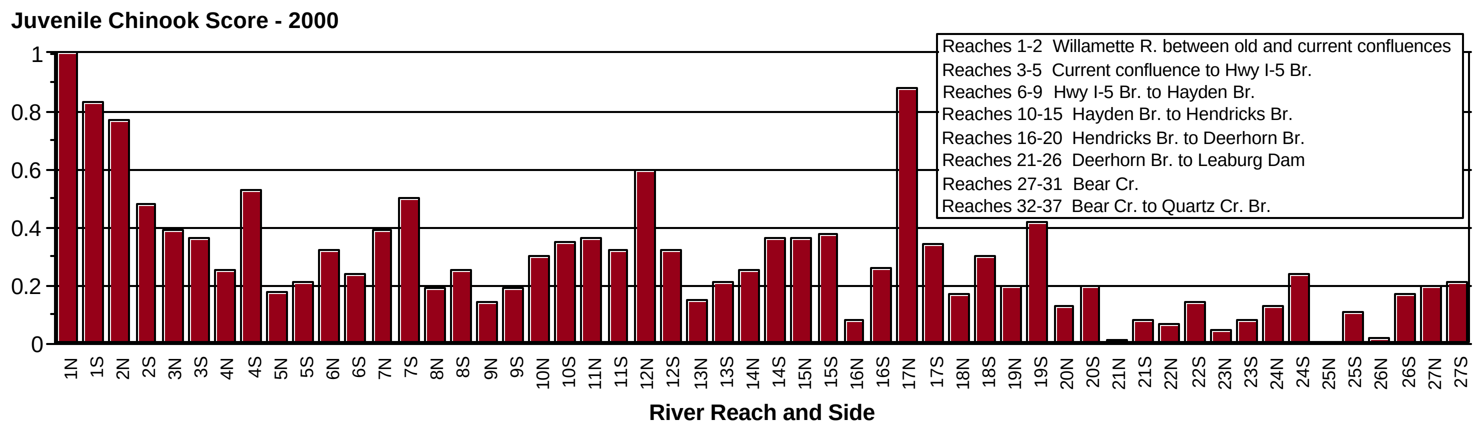
Comparing current and historic juvenile chinook habitat scores

The methodology used in the above examples to describe current habitat quality can be modified to compare historic and current habitat quality. This may be desirable in order to identify reaches that possibly had good habitat, examine the current habitat quality, and highlight where good potential habitat and poor current habitat coincide. These reaches could receive high priority for restoration. The 1944 aerial photographs extend only to Leaburg Lake so the following analysis will include only the most downstream 27 reaches. Field data for riffle length and riprap length are not available for 1944 and no gravel pit ponds existed then so the variables available for analysis are:

Alcove area
Side channel area
Natural ponds area
Island area
Main channel area
Bare substrate area
Older trees area

Weights for each of the seven variables were assigned as shown in Table 3-2. The seven variables were standardized, multiplied by their respective weights and then summed. These summed scores are then standardized to end up with a juvenile chinook habitat score between 0 and 1 for each of the 1944 and 2000 databases (Figure 3-4).

Results of this analysis indicate that, in general, those reaches that currently have high quality habitat also had higher quality habitat in 1944. Exceptions include reaches #3 and #4 where the river was channelized to allow gravel extraction. For both periods, juvenile salmon habitat was below average upstream of reach #19. In this upstream segment, the valley narrows and keeps the river from meandering much. Consequently, the river is less complex compared to the downstream reaches. A summary of reaches that had considerable declines in juvenile chinook habitat quality is provided in Table 3-2b.



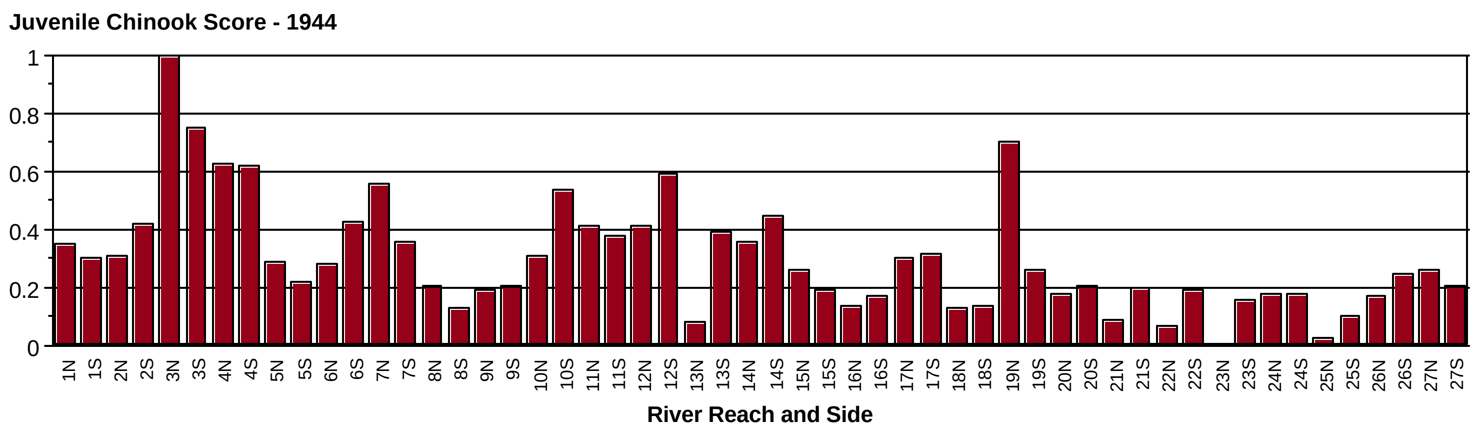


Figure 3-4. Combined fish scores for 2000 and 1944 conditions by side of reach from the old McKenzie confluence to Leaburg Lake.

Table 3-2b. Reaches (by side) that had high fish habitat scores in 1944 but human or natural influences now limit fish habitat quality and major enhancements would need to occur to improve habitat quality.

Reach	Positive factors	Limiting factors
1N	Many alcoves, side channels, ponds, and islands. Flood-prone area not suitable for development. Some older hardwoods along bank.	Old McKenzie channel does not have summer flow. Enhancement would be to provide regulated flow into the old channel.
2N	Alcoves, side channels, ponds, and islands. Flood-prone area not suitable for development.	Old McKenzie channel does not have summer flow. Enhancement would be to provide regulated flow into the old channel.
3S	Once was part of delta dissected by many side channels.	Intensive diking and riprap. Gravel extraction areas immediately behind dikes. Enhancement would include providing downstream connection to river for some gravel ponds
4S	Includes islands, alcoves, and side channels. Lower portion once was part of delta dissected by many side channels	Intensive diking and riprap. Gravel extraction areas and processing facilities immediately behind dikes. Enhancement would be to increase extent of side channels and alcoves.
12S	Expansive flood-prone area that includes Cedar Creek. Many ponds and some alcoves.	Major side channel (now a series of ponds) no long has summer flow. Enhancement would be to provide summer flow to side channel.
15S	Tight bend in river creates extensive meandering and side channels.	River front home located precariously in meander area. Landowner recently removed log jam and opened side channel at base of bend which could cause river to abandon current main channel. Enhancement would be to add key pieces of large wood at head of side channel to keep most flow in main channel.

Juvenile spring chinook habitat at McKenzie River tributary junctions

Juvenile spring chinook salmon often use habitats other than the main channel of the McKenzie River during the winter and spring. They occupy pockets of slower water adjacent to the main channel, including the downstream end of tributary streams, side channels, ponds, and alcoves. This behavior is probably tied to strategies of conserving energy, resisting downstream displacement, avoiding predation by large trout, and increasing feeding opportunities.

Tributary junctions provide a special type of off-channel habitat, especially where the tributary stream extends upstream at a gentle gradient. Young salmon will back into these streams during high water, seeking refuge from fast water and food. The condition of many of these low-gradient streams is often less than ideal due to a loss of complex structure. Usually, large wood in the channel is what provides that complex structure. Restoring this complex structure by intentionally placing large logs in tributary channels is one way to increase overall habitat quality for juvenile chinook salmon in the McKenzie River.

The purpose of this section is to determine which tributary streams of the McKenzie River are most suited for intentional placement of large wood and thereby, enhancing spring and winter habitat for juvenile chinook salmon. We have constructed a rating system that takes into account potential habitat quality and log placement logistics.

<u>Tributary rating.</u>
The ability of logs to be stable in a channel is largely a function of the stream size and length of the wood added to the stream. Barring expensive cabling, the wood needs to be about twice the bankfull width of the channel to ensure stability. The Oregon Department of Forestry has classified streams in Oregon according to three size classes; small streams have an average annual flow less than 2 cfs, medium-sized streams have a flow between 2 and 10 cfs, and large streams have an average annual flow greater than 10 cfs. Medium-sized streams are usually good candidates for wood placement since they are large enough to provide adequate water depth for fish while narrow enough to make it possible to find logs of sufficient length. On average, a medium size stream with an average annual flow of 2 cfs has a bankfull width of 12 feet and 22 feet for an average annual flow of 10 cfs. These estimates were made using a relationship developed for 64 streams in southwest Washington; $width = 9.54 * flow^{0.369}$. These bankfull widths correspond to stable log lengths of 24 feet for 2 cfs and 44 feet for 10 cfs.

Young juvenile chinook usually prefer low gradient tributaries. A gradient of 4% was selected as a maximum for these fish and less than 2% greater was considered prime habitat because of the slow water. Using the Oregon Department of Forestry stream size maps and the USGS topographic maps, we were able to isolate 14 medium-sized tributaries of the McKenzie River that had at least 300 feet of channel upstream of their mouths and at a gradient of less than 4%. The total length of channel less than 4% was measured off the map, as well as the length less than 2% gradient. We assumed that tributaries with low gradient channel have greater habitat restoration potential.

Using aerial photographs, we then noted what percentage of the lower tributary less than 4% gradient was bordered by trees. We assumed that those tributaries with more complete tree cover were more capable of supplementing large wood accumulations in the channel over time.

We then examined the aerial photographs for medium-sized lower tributaries that had connected ponds. We assumed that these ponds were a bonus to juvenile chinook habitat since they greatly increase living space, have deep water, and had low velocity flow.

Finally, using aerial photographs, we determined the number of houses bordering the lower end of the tributaries and assumed that the logistics of securing cooperation for log placement from landowners were least complicated where fewer houses existed.

Scores were assigned to each of the five factors that we chose and an overall suitability rating calculated, as shown below:

Factor	Scores
1. Channel length less than 4% gradient	>3500ft = 5, 800-3500ft = 3, 300-800ft = 1, <300ft = 0
2. Channel length less than 2% gradient	>2000ft = 5, 500-2000ft = 3, 200-500ft = 1, <200ft = 0
3. Percent of channel bordered by trees	80-100% = 5, 50-80% = 3, 10-50% = 1
4. Whether or not a pond exists	Yes = 5, No = 0
5. Abundance of houses	None = 5, 1-3 = 3, >3 = 1

A total scoring was obtained by adding the 5 individual scores. The total scores were then segregated into three ratings as indicated; 18-20 = High, 13-16 = Moderate, 9-11 = Low. A summary of the scorings and rating are shown in Table 3-3 and indicates that Goose Creek, Lane Creek, Boulder Creek, an unnamed stream entering reach #11 from the south, and Haagen Creek are rated as having the highest potential for providing high quality habitat for juvenile chinook.

Table 3-3. Medium-Sized Tributaries of the McKenzie River between the Willamette River Confluence and Quartz Creek.

A ID #	B Name	C Reach	D Side Entering	E 0-2% Gradient Distance (ft)	F 2-4% Gradient Distance (ft)	G 0-4% Gradient Distance (ft)	H % Trees	I Pond?	J Houses ?	K Points; 0-4% Gradient Distance (ft)	L Points; 0-2% Gradient Distance (ft)	M Points % Trees	N Points Pond	O Points Houses	Q Points Total	R Rating
14	Rough Cr	31	North	0	300	300	100	No	Few	1	0	5	0	3	9	Low
3	Osborn Cr	17	South	0	2700	2700	100	No	Few	3	0	5	0	3	11	Low
12	Toms Cr	29	South	0	900	900	100	No	Few	3	0	5	0	3	11	Low
13	Rails Cr	31	North	0	1000	1000	100	No	Few	3	0	5	0	3	11	Low
9	Holden Cr	21	North	0	3900	3900	100	No	Few	5	0	5	0	3	13	Medium
5	Potter Cr	19	North	3400	1000	4400	70	No	Many	5	5	3	0	1	14	Medium
11	Hatchery Cr	27	North	0	400	400	100	Yes	Few	1	0	5	5	3	14	Medium
2	Cedar Cr	14,15,16	South	10300	2800	13100	100	No	Many	5	5	5	0	1	16	Medium
7	Forest Cr	20	South	2900	0	2900	100	No	Few	3	5	5	0	3	16	Medium
8	Haagen Cr	20	South	4200	900	5100	90	No	Few	5	5	5	0	3	18	***High***
1	Tributary #1	11	North	1500	0	1500	80	Yes	Few	3	3	5	5	3	19	***High***
4	Boulder Cr	17	South	1800	0	1800	100	Yes	Few	3	3	5	5	3	19	***High***
6	Lane Cr	20	North	5300	900	6200	30	Yes	Few	5	5	1	5	3	19	***High***
10	Goose Cr	24	South	4400	1200	5600	100	No	None	5	5	5	0	5	20	***High***

Column Definition

A	Identification number for stream, increasing in an upstream direction
B	Tributary name
C	The river reach corresponding to the tributary confluence
D	Side of river that tributary enters
E	Length of downstream end of tributary stream for which the gradient is less than 2%
F	Length of downstream end of tributary stream for which the gradient is between 2% and 4%
G	Length of downstream end of tributary stream for which the gradient is less than 4%
I	Percent length of channel less than 4% that is bordered by trees
J	Indicates whether or not a pond exists within or near the stream
K	Indicates number of houses near the stream; none, few (1-3 houses), or many (>3 houses)
L	Points – distance (feet) for which channel gradient is between 0 and 4%; >3500ft = 5, 800-3500ft = 3, 300-800ft = 1, <300ft = 0
M	Points – distance (feet) for which channel gradient is between 0 and 2%; >2000ft = 5, 500-2000ft = 3, 200-500ft = 1, <200ft = 0
N	Points – Percent length of channel less than 4% that is bordered by trees; 80-100% = 5, 50-80% = 3, 10-50% = 1
O	Points – whether or not a pond exists within or near the stream; yes = 5, no = 0
P	Points - number of houses near the stream; none = 5, 1-3 = 3, >3 = 1
Q	Points - Total (columns K through O)
R	Relative ranking; 18-20 = High, 13-16 = Moderate, 9-11 = Low

Literature Cited

Aquatic Ecosystem

Abbe, T.B. and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers Research and Management 12:201-221.

Andrus, C.W. 2000. Spring and summer fish assemblages of the Willamette River near Eugene. Report prepared for the City of Eugene, Oregon. 43 p.

Andrus, C.W., J. Gabriel, and P. Adamus. 2000. Biological evaluation of the Willamette River and McKenzie River Confluence Area. Report prepared for the McKenzie Watershed Council, Eugene. 48 p.

Andrus, C.W., B.A. Long, and H.A. Froehlich. 1988. Woody debris and its contribution to pool formation 50 years after logging. Can. J. Fish. Aquat. Sci. 45:2080-2086.

Aquatic Biology Associates. 2000. Benthic invertebrate biomonitoring for the McKenzie River Watershed Council, Oregon. Report for the McKenzie River Watershed Council.

Bayley, P.B. and C.F. Baker. Floodplain restoration in off-channel habitats used for gravel mining in the Willamette River Basin. Report to the Willamette River gravel removal restoration fund program. 21 p.

Beechie, T.J. and T.H. Sibley. Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams. 1997. Trans. Amer. Fish. Soc. 126:217-229.

Bilby R.E. and J.W. Ward. 1991. Changes in characteristics and function in streams draining old-growth, clear-cut, and second-growth forests in southwest Washington. Can. J. Fish. Aquat. Sci. 48:2499-2508.

Bilby R.E., B.R. Fransen, P.A. Bisson, and J.K. Walter. 1998. Response of juvenile coho salmon (Oncorhynshus kisutch) and steelhead (Oncorhynchus mykiss) to the addition of salmon carcasses to two streams in southwestern Washington, U.S.A. Can. J. Fish. Aquatic Sci. 55:1909-1918.

Bradford, M.J. 1997. An experimental study of stranding of juvenile salmonids on gravel bars and in side channels during rapid flow decreases. Regulated Rivers: Research and Management 13:395-401.

Cude, C. 2000. McKenzie watershed water quality report: water years 1990-1999. Report prepared by the Oregon Department of Environmental Quality, Portland. 49 p.

EA Engineering, Science, and Technology. 1990. A study of the aquatic insects of the lower McKenzie River, Oregon. Reported prepared for the Eugene Water and Electric Board. 17 p.

EA Engineering, Science, and Technology. 1994. Temperature modeling study of the lower McKenzie River, Oregon 1993. Reported prepared for the Eugene Water and Electric Board. 19 p.

Everest, F.H. and D.W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. J. of the Fish. Res. Board of Canada 27:1215-1244.

Freidman, J.M., W.R. Osterkamp, M.L. Scott, and G.T. Auble. 1998. Downstream effects of dams in channel geometry and bottomland vegetation: regional patterns in the Great Plains. Wetlands 18:619-633.

Gippel, C.J. 1995. Potential of turbidity monitoring for measuring the transport of suspended solids in streams. Hydrological Processes 9:83-97.

Harvey, B.C., R.J. Nakamoto, and J.L. White. 1999. Influence of large woody debris and a bankfull flood on movement of adult resident coastal cutthroat trout (*Oncorhynchus clarki*) during fall and winter. Can. J. Fish. Aquat. Sci. 56:2161-2166.

Huntington, C.W. 2000. A supplemental assessment of the Mohawk watershed. Draft report prepared for the Mohawk Watershed Partnership. 61 p.

Knudson, E.E. and S.J. Dilley. 1987. Effects of riprap bank enforcement on juvenile salmonids in four western Washington streams. N. Amer. J. of Fisheries Mgt. 7:351-356.

Ligon, F.K. 1991. The fluvial geomorphology of the lower McKenzie River. Report by EA Engineering, Science, and Technology for the Eugene Water and Electric Board, Oregon. Variously paged.

Lyons, J.K., and R.L. Beschta. 1983. Land use, floods, and channel changes: Upper Middle Fork Willamette River, Oregon (1936-1980). Water Resources Research 19(2):463-471.

Miller, J.R., T.T. Schulz, N.T. Hobbs, K.R. Wilson, D.L. Schrupp, and W.L. Baker. 1995. Changes in the landscape structure of a southeastern Wyoning riparian zone following shifts in stream dynamics. Biological Conservation 72:371-379

Mattson, C. and C. Jensen. 1952. Flow studies of the McKenzie River between the Walterville canal inlet and outlet, summer and fall of 1952. 44 p.

Mattson, K., S. Coveny, B. Johnson, J. Means, W. Weaver, T. Williamson, J. Reams, and B. Rosenbaum. 1998. Quartz Creek and minor tributaries watershed analysis. Report to Blue River Ranger District, Willamette National Forest. 123 p.

McKenzie Watershed Council. 2000. 1998 storm event monitoring pilot results (draft). 25 p.

Pearsons, T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. Trans. Am. Fish. Soc. 121:427-436.

Pulford, E.R. and C. Jensen. 1956. Flow investigation of the McKenzie River from the Leaburg Dam to the outlet of the Leaburg power diversion canal, summer and fall of 1955.

Richards, C., P.J. Cernera, M.P. Ramey, and D.W. Reiser. 1992. Development of off-channel habitats for use by juvenile chinook salmon. N. Am. J. of Fish. Mgt. 12:721-727.

Robison, E.G., K.A. Mills, J. Paul, L. Dent, and A. Skaugest. 1999. Storm impacts and landslides on 1996. Forest Practices Technical Report Number 4, Oregon Department of Forestry. 145 p.

Runyon, J. 2000. McKenzie Watershed Council 1998 storm event monitoring pilot results (review draft). 25 p.

Sedell, J.R. and F.L. Froggatt. 1984. Importance of streamside forests to large rivers: The isolation of the Willamette River, Oregon, U.S.A., from its floodplain by snagging and streamside forest removal. Verh. Internat. Veein. Limnol. 22:1828-1834.

Swales, S., and C.D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Coldwater River, British Columbia. Can. J. Fish. Aquat. Sci. 46:232-242.

Taylor, E.B. 1988. Water temperature and velocity as determinants of microhabitats of juvenile chinook and coho salmon in a laboratory stream channel. Trans. Am. Fish. Soc. 117:22-28.

Torgersen, C.E., R.N. Fauz and B.A. McInosh. 1999. Aerial survey of the upper McKenzie River – thermal infrared and color videography. Unpublished report. Oregon State University, Corvallis. 20 p.

U.S. Corps of Engineers (USCE). 2000. Water quality studies at Cougar Lake, Blue River Lake, and the McKenzie River, Oregon. Draft miscellaneous paper. 34 p.

USDA Forest Service. 1995. Upper McKenzie Watershed Analysis. Willamette National Forest, Eugene, OR.

Van Steeter, M.M. and J. Pitlick. 1998. Geomorphology and endangered fish habitats of the upper Colorado River: 1. Historic changes in streamflow, sediment load, and channel morphology. Water Resources Research 34(2):287-302.

Weyerhaeuser Company. 1994. Lower McKenzie River watershed analysis (south side). Variously paged.

Fish species in the McKenzie River

Andrus, C.W., J. Gabriel, and P. Adamus. Biological evaluation of the Willamette River and McKenzie River Confluence Area. Report prepared for the McKenzie Watershed Council, Eugene. 48 p.

Behnke, R.J. 1992. Native trout of western North America. Bethesda: American Fisheries Society.

Groot, C. and L. Margolis 1991. Pacific salmon life histories. Vancouver: UBC Press.

Hardin-Davis, Inc., Hosey & Associates Engineering Co., Clearwater Biostudies, Inc. 1990. Habitat suitability criteria for salmonids of the McKenzie River. Prepared for the Eugene Water and Electric Board.

Oregon Department of Fish and Wildlife 1999. Fish of the McKenzie River. ODFW website URL: http://www.dfw.state.or.us/springfield/McKFish.html.

Priority Vegetation Types

Allen, Jennifer, Autumn Salamack, and Peter Schoonmaker. 1999. Restoring the Willamette Basin: Willamette Restoration Initiative. Institute for the Northwest.

Boag, P.G. 1992. Environment and experience: Settlement culture in nineteenth-century Oregon. University of California Press, Berkeley. 209 p.

Chiller, D.G. and D.G. Vesely. 2000. Assessment of Oak Woodland Resources in BLM's Eugene District. USDA Bureau of Land Management National Applied Resource Sciences Center BLM/OR/WA/PL-00/052+6635. pp. 98.

Christy, J.A., E.R. Alverson, M.P. Dougherty and S.C. Kolar. 1997. Provisional classification of "presettlement" vegetation in Oregon, as recorded by general land office surveyors. Oregon Natural Heritage Program. The Nature Conservancy of Oregon Unpublished report. pp. 8.

Franklin, J.F. and C.T. Dyrness. 1988. The natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, OR. 452 p.

Johannessen, C.L., W.A. Davenport, A. Millet and S. McWilliams. 1971. The vegetation of the Willamette Valley. Association of American Geographers, Annals 61:286-302.

Shelly, J. R. 1997. An examination of the oak woodland as a potential resource for higher-value wood products. Pp. 445-455, In, N.H. Pillsbury, J.

Thilenius, J.F. 1968. The *Quercus garryana* forests of the Willamette Valley, Oregon. Ecology 49:1124-1133.

Towle, J.C. 1982. Changing geography of Willamette Valley woodlands. Ore Hist Q 83:66-87.

USDA Willamette National Forest, USDI Salem District BLM, USDI U.S. Fish and Wildlife Service OSO. 1998. Willamette Late-successional Reserve Assessment: version 1.0. Available at http://www.fs.fed.us/r6/willamette/mgmt/lsr/lsr.htm

Verner, W.D. Tietje, Tech Coords., Proceedings of a symposium on oak woodlands: ecology, management, and urban interface issues. USDA Forest Service, Pacific Southwest Research Station. General Technical Report PSW-GTR-160. Albany, CA.

Avian Species of Concern

Allen, Jennifer, Autumn Salamack, and Peter Schoonmaker. 1999. Restoring the Willamette Basin: Willamette Restoration Initiative. Institute for the Northwest.

Altman, B. Personal Communication. American Bird Conservancy/ Oregon Washington Partners in Flight Co-chair. 18000 SE Vogel Road, Boring, Oregon. Alt8bird@aol.com

Altman, B. 2000. Conservation strategy for landbirds in lowlands and valleys of western Oregon and Washington. Version 1.0, Prepared for Oregon-Washington Partners in Flight. Available at http://community.gorge.net/natres/pif.html.

Altman, B. 1999. Conservation strategy for landbirds in coniferous forests of western Oregon and Washington. Version 1.0. Prepared for Oregon-Washington Partners in Flight. Available at http://community.gorge.net/natres/pif.html.

Csuti, Blair, A. Jon Kimerling, Thomas A. O'Neil, Margaret M. Shaughnessy, Eleanor P. Gaines, and Manuela M. P. Huso. 1997. Atlas of Oregon wildlife: distribution, habitat, and natural history. Oregon State University Press, Corvallis.

Gabrielson, Ira N. and Stanley G. Jewett. 1970. Birds of the Pacific Northwest. Dover Publications, New York.

Gullion, Gordon W. 1951. Birds of the southern Willamette Valley, Oregon. Condor 53: 129-149.

Lane Council of Governments. 1996. Technical report for water quality and fish and wildlife habitat. Prepared for the McKenzie Watershed Council.

Marshall, D. B., M. G. Hunter, and A. C. Contreras. In prep. Birds of Oregon: A general Reference. Oregon State University Press, Corvallis. (http://www.orst.edu/pubs/birds/bogr/index.htm)

Oregon Department of Fish and Wildlife. 2000. Landowner's guide to creating grassland habitat for the western meadowlark and Oregon's other grassland birds. Portland, Oregon Department of Fish and Wildlife.

Oregon Department of Forestry. 1996. Forest Practices Act Changes: Update. Oregon Department of Forestry, Salem.

Petit, Daniel R. 2000. Habitat use by landbirds along neartic-neotropical migration routes: implications for conservation of stopover habitats. Studies in Avian Biology No. 20: 15-33.

Sauer, J. R., J. E. Hines, I. Thomas, J. Fallon, and G. Gough. 2000. The North American Breeding Bird Survey, Results and Analysis 1966 - 1999. Version 98.1, *USGS Patuxent Wildlife Research Center*, Laurel, MD. (http://www.mbr-pwrc.usgs.gov/bbs/bbs.html)

Sauer, J. R., S. Schwartz, and B. Hoover. 1996. The Christmas Bird Count Home Page. Version 95.1. Patuxent Wildlife Research Center, Laurel, MD. *(*http://www.mbr.nbs.gov/bbs/cbc.html*)*

Western Pond Turtle

Hayes, M.P. 1992. Habitat suitability model for the western pond turtle (*Clemmys marmorata*). Unpublished manuscript. 36 p.

Holland, D.C. 1994. The western pond turtle habitat and history. U.S. Department of Energy and Bonneville Power Administration Project Number 92-068.

Rathbun, G.B., N. Speipel and D.C. Holland. 1992. Nesting behavior and movements of western pond turtles, *Clemmys marmota*. Southwestern Naturalist 37:319-324.

Van Horne, B. and J.A. Wiens. 1991. Forest bird Habitat Suitability Models and the development of general habitat models. U.S. Fish and Wildlife Service Fish and Wildlife Research Number 8.

Appendix 1

Appendix 1A. McKenzie River Timeline

1700's-early 1880's - Hudson's Bay Company claims territory
1812-Donald Mackenzie discovered the river
1826- David Douglas explores Eugene/Springfield area
1834 -John Work heads journey to the Umpqua that includes an expedition up the McKenzie by canoe
1848- Oregon Territory
1848-The first settler to present day Eugene, Elias M. Briggs. The Briggs family operated a ferry across the river at roughly the site of the railroad bridge
1848-1945-16 mills separated by 7 lumber companies in Mohawk Valley
1850-Land Donation Act of 1850 played a major role in attracting early settlers to farmland of the lower McKenzie
1840's-1850's-Booth Kelly Lumber Company settled in Mohawk valley for business
1850's-Mohawk River valley had many mills serving local lumber demands
1851-Flood
1852-Flood
1852-A canal now called the Millrace was dug and the power from this source ran the Grist mill
1853-Grist sawmill was built (one of the first 2 built in Springfield)
1860's-McKenzie Wagon Road was built connecting western and eastern Oregon
-Gold deposits found on the Blue River and hot springs were found on the McKenzie and Horse Creek
1861-Flood
1862-Homestead Act attracted people to the area
1862-Flood
1862-The beginning of (cattle) drives from the upper Willamette through McKenzie and Minto passes in the Cascade Range
1860's & 1870's-Homesteads spread upstream and away from the riverbanks
1872-Oregon and California Railroad increased settlement in the area
1875-Flood
1881-Flood
1882-Flood
1885- Springfield incorporated as a city.
1890-Big Flood
1890's Development started around the gold areas and hot spring activities and began to have a substantial impact on the cultural landscape
1904-Oregon's first trout hatchery built near Leaburg Dam
1904-The Willamette Valley Electric Railway incorporates to build a network of interurban through Lane and Benton counties. Power would come from the company's own generators to be located at Martin Ferry on the McKenzie.
1907-Old McKenzie Fish Hatchery was built
1907-Feb. 5-Flood 13.26 ft. above the gage at Hendrick's Ferry

1909 -Nov. 22-Flood 14.53 ft. above the gage at Hendrick's Ferry
By 1910- Mohawk Valley floor by Marcola, Wendling, and Mabel was a big lumber factory
1911- First Streetcar in Springfield. (Some complained that this would turn Springfield and Eugene into one city!)
1911-The McKenzie Project began
1912-Jan. 12-Flood 12.1 ft. above the gage at Hendrick's Ferry
Until 1913-Loggers used river to transport logs
1920-Prince Helfrich begins guiding service on the McKenzie
1923-January. 6th-Flood 8.3 ft. above the gage at McKenzie Bridge
1927-Feb. 20th-Flood 14.2 ft. above the gage near Vida and 6.8 ft. above the gage at McKenzie Bridge
1928-A measure was proposed which would close the Rogue, McKenzie, Deschutes, and Umpqua rivers to any diversion of their waters for industrial purposes. Later defeated.
1929-Leaburg dam was constructed
1930-Reconstruction and improvement on the McKenzie Highway.
By 1930's-12 small mills along the McKenzie
1939-March 8-Muddy Creek Irrigation Project began
1942-Dec. 31-Flood 7.07 ft. above the gage at McKenzie Bridge
1943-Jan. 1-Flood 14.6 ft. above the gage near Vida
1945-Dec. 28-BIG flood 17.7 ft. above the gage near Vida
1946-Dec. 14 & 15-Flood 12.2 ft. above the gage near Vida and 6.63 ft. above the gage at McKenzie Bridge
1948-Jan. 7-Flood 12.16 ft. above the gage near Vida and 6.64 ft. above the gage at McKenzie Bridge
By 1940's-Lumber companies commonly trucked logs out of the valley to mills in Springfield
1950's-Lumber mill era ended in Mohawk and mills moved to Springfield
1953-Hatchery closed after Eugene Water and Electric Board built the Leaburg dam
1953-Jan. 18-Flood 15.03 ft. above the gage near Vida and 7.68 ft. above the gage at McKenzie Bridge
1953-Nov. 23-Flood 12.22 ft. above the gage near Vida
1955-Dec. 22-Flood 15 ft. above the gage near Vida and 7.79 ft. above the gage at McKenzie Bridge
1956-Dec. 11-Flood 13.73 ft. above the gage near Vida and 6.23 above the gage at McKenzie Bridge
1961-Feb. 10-Flood 12.28 ft. above the gage near Vida and 6.34 ft. above the gage at McKenzie Bridge
1964-Dec. 22-BIG flood 16.43 ft. above the gage near Vida and 10.36 ft. above the gage at McKenzie Bridge
1988-A 12.7 mile stretch from Clear Lake to Scott Creek was designated as being a National Wild and Scenic River
1996-Feb. 7-Flood 10.05 ft. above the gage near Vida

Appendix 2

Appendix 2A. Description of NWI systems used in this report and Glossary of other terms.

Lacustrine System

Definition. The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 ha (20 acres). Similar wetland and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 2 m (6.6 feet) at low water. Lacustrine waters may be tidal or nontidal, but oceanderived salinity is always less than 0.5%. (From Cowardin et al. 1979)

Palustrine System

Definition. The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2 m at low water; and (4) salinity due to ocean-derived salts less than 0.5%. (From Cowardin et al. 1979)

Glossary

Basin migrants: Species that breed in the Cascades and winter in the Willamette Valley.
Breeding Bird Survey: A nationwide, roadside survey of breeding birds that is conducted annually across the United States and Canada. Results from the last 33 years are available at http://www.mbr-pwrc.usgs.gov/bbs/
Cascade Mountain Region: Breeding Bird Survey region used for analysis. Includes areas of the Cascade Range in Oregon and Washington.
Cavity-nesting bird: A species that nests in cavities. Includes birds that excavate their own cavities and birds that require pre-existing cavities for nesting.
Christmas Bird Count: A nationwide, roadside survey of wintering birds that is conducted annually across the United States and Canada. Results from 1959 to 1988 are available at http://www.mbr.nbs.gov/bbs/cbc.html
Dbh: Diameter at breast height; the diameter of a tree at 4 ½ feet (approximately breast height)
Early-seral: Typically young forests

Late seral: Typically older forests
Gallery Forest: A narrow strip of forest that occurs along a river or stream in an otherwise unwooded area (i.e., riparian forests within the Willamette Valley).
Lacustrine Wetland: includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergent plants, emergent mosses or lichens with greater than 30% aerial coverage; and (3) total area exceeds 8 ha (20 acres).
Neotropical Migrant: Species that breed in the McKenzie basin during summer and winter south of the United States.
Oak Savannah: A vegetation type in which oaks are scattered and spaced far apart; usually has an understory dominated by grasses and herbaceous plants.
Oak Woodland: A vegetation type in which oaks occur as a closed-canopy forest (or virtually so), often with an understory of subcanopy oaks, maples, and shrubs.
Other Migrants: Species that breed elsewhere and that move into the McKenzie basin during winter and species that breed in McKenzie basin during summer and winter in areas north of Mexico.
Palustrine wetland: includes all nontidal wetlands dominated by trees, shrubs, persistent emergent plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2 m at low water; and (4) salinity due to ocean-derived salts less than 0.5%. (From Cowardin et al. 1979)
P-value: For the population trend analysis, the P-value is a statistical value that represents the probability that there is no change in the population. A low P-value indicates a high probability that there is a real, and significant change happening in the population of birds for that particular species.
Reach: An area of the river that is 0.5 to 2.0 miles long and that has a somewhat uniform channel shape and complexity.
Resident: Species that occur in a given area in both summer and winter, and includes species that remain on their home range year-round and species that migrate short distances such that different individuals occur in an area in different seasons.
Riparian Forest: A forest that is associated with a river or stream; it can occur in wooded or unwooded areas.
Seral: Relates to the age of a forest
Species of Concern: A species of bird that has a significant ($P<0.1$) declining trend in their population based on analysis of Breeding Bird Survey data from the appropriate region reflecting it's breeding range in Oregon or elsewhere or from analysis of Christmas Bird Count data for Oregon.
Willamette Basin Region: Breeding Bird Survey region used for analysis. Includes the Willamette Valley of Oregon and the Puget Lowlands of Washington.

Appendix 2B. Avian Species of Concern in the McKenzie Basin, Oregon and their population trends in Oregon. Long term (lt; 1966-1999) and short term (st; 1980-1999) population trends (% change per year) are listed for species with significant (P≤0.10) declining population trends in Oregon, the Willamette Basin, or in the Cascade Range; all trends with P≤0.20 are listed; P-values are shown in parentheses.

Species	Trend Analysis Results					
	Oregon, lt	Oregon, st	Valley, lt	Valley, st	Cascades, lt	Cascades, st
Acorn Woodpecker						
American Crow					-3.8 (0.08)	
American Goldfinch	-3.6 (0.00)		-4.7 (0.02)	-4.3 (0.08)		
American Kestrel					-10.1 (0.05)	-34.4 (0.01)
American Robin	-1.4 (0.00)	-1.5 (0.03)				
Bald Eagle						
Band-tailed Pigeon	-1.8 (0.01)	-7.3 (0.01)				-6.0 (0.01)
Barn Swallow	-2.3 (0.01)		-1.9 (0.05)	-2.5 (0.02)		
Belted Kingfisher	-2.6 (0.03)	-2.4 (0.07)				
Black-capped Chickadee	-1.8 (0.04)					
Black-crowned Night Heron						
Brewer’s Blackbird	-2.9 (0.03)	-3.8 (0.00)	-4.8 (0.00)	-5.3 (0.00)		
Brown Creeper					-5.5 (0.04)	
Burrowing Owl						
Cedar Waxwing	-2.5 (0.02)	-4.4 (0.06)				
Chestnut-backed Chickadee	-7.1 (0.00)					
Chipping Sparrow	-4.6 (0.00)					
Common Goldeneye						
Common Nighthawk						
Cooper’s Hawk					-3.4 (0.19)	-8.4 (0.02)
Downy Sapsucker				-8.1 (0.00)		
Fox Sparrow	-3.0 (0.01)	-4.9 (0.01)				
Golden Eagle						
Golden-crowned Kinglet	-5.7 (0.00)	-4.0 (0.03)				
Grasshopper Sparrow						
Great Gray Owl						
Horned Lark						
Killdeer	-4.1 (0.00)	-3.8 (0.01)			-3.9 (0.17)	-11.6 (0.03)
Lesser Goldfinch	-6.0 (0.03)					
Lewis' Woodpecker						
MacGillivray’s Warbler	-2.3 (0.09)	-1.8 (0.13)				
Mourning Dove	-2.5 (0.00)	-1.6 (0.03)				
Nashville Warbler		-2.6 (0.01)				

Northern Goshawk	-13.5 (0.08)				-8.5 (0.14)	
Northern Pintail						
Northern Pygmy-owl					-9.2 (0.04)	
Olive-sided Flycatcher	-5.0 (0.00)	-3.1 (0.04)	-7.9 (0.14)		-3.2 (0.00)	-3.6 (0.01)
Orange-crowned Warbler	-3.5 (0.0)	-6.9 (0.00)				
Osprey						
Pacific-slope Flycatcher	-3.8 (0.01)	-5.0 (0.03)				
Pileated Woodpecker						
Pine Siskin		-9.2 (0.01)		-10.9 (0.06)		-5.2 (0.08)
Purple Finch		-6.0 (0.00)				
Purple Martin						
Red-breasted Nuthatch	-1.8 (0.00)	-2.4 (0.03)			-1.1 (0.15)	
Red-eyed Vireo		-0.6 (0.04)				
Rufous Hummingbird	-5.0 (0.00)	-4.9 (0.01)	-3.1 (0.16)		-2.6 (0.01)	-4.9 (0.00)
Savannah Sparrow			-3.3 (0.09)			
Song Sparrow	-1.4 (0.00)					
Spotted Owl						
Swainson's Thrush	-1.9 (0.00)	-2.6 (0.00)				
Varied Thrush						-2.0 (0.01)
Vaux's Swift						-6.1 (0.09)
Vesper Sparrow						
Violet-green Swallow	-1.8 (0.04)					
Western Bluebird						
Western Meadowlark	-0.7 (0.18)	-1.7 (0.02)	-19.2 (0.01)	-22.4 (0.03)	-32.0 (0.06)	**
Western Tanager	-1.4 (0.04)					
Western Wood-pewee	-3.3 (0.00)				-3.1 (0.17)	
White-breasted Nuthatch		-2.9 (0.16)	-10.0 (0.02)	-18.8 (0.00)	-5.3 (0.05)	-12.4 (0.04)
White-crowned Sparrow	-4.2 (0.00)	-2.6 (0.06)				
Willow Flycatcher	-5.7 (0.02)	-3.3 (0.00)	-4.1 (0.25)			
Wilson's Warbler		-2.0 (0.07)				
Yellow-billed Cuckoo						
Yellow-breasted Chat						

** There was no significant short-term trend in the Cascades because numbers had declined to close to zero by 1980; thus there was little change because all values between 1980 and 1999 were near or equal to zero.

Appendix 2C. Summary of geographical range, migration status, habitat guild, historical status, and current status for avian species of concern. Species most in need of conservation efforts (as indicated by a state or federal listing or by a decline in population of > 10% per year in the area that best represents a core area of their range, in more than one location, or at both short- and long-term time periods) are noted in bold.

Species	Range in study area	Migratory Status	Habitat Guild[1]	Historical Status in Valley/Foothills	Current Status
Acorn Woodpecker	Valley	Resident	Oak/ SF[2]	Common	
American Crow	Cascades/ valley	Resident	Multiple	Abundant	Declining BBS
American Goldfinch	Cascades/ valley	Resident	Shrub/ SF[2]	Very Common	Declining BBS
American Robin	Cascades/ valley	Resident	Multiple	Abundant	Declining BBS
American Kestrel	**Valley/ Cascades**	**Resident**	**Multiple/ SF[2]**	**Very Common**	**Declining BBS**
Bald Eagle	**Cascades/ valley**	**Resident**	**Water/ SF[2]**	**Uncertain**	**State Threatened**
Band-tailed Pigeon	Cascades	Resident	Conifer/ SF[2]	Common	Declining BBS
Barn Swallow	Valley/ Cascades	Neotropical Migrant	SF[2]	Uncommon	Declining BBS
Belted Kingfisher	Cascades/ valley	Resident	Water/ SF[2]	Common	Declining BBS
Black-capped Chickadee	Valley	Resident	Riparian/ Oak/ SF[2]	Very Common	Declining BBS
Black-crowned Night Heron	Winters in valley	Other Migrant	Water	Not noted	Decl. BBS[3] and CBC
Black Swift	**Cascades**	**Neotropical Migrant**	**SF[2]**	**Not noted**	**State Sensitive**
Brewer's Blackbird	Cascades/ valley	Resident	Multiple	Abundant	Declining BBS
Brown Creeper	Cascades/ valley	Resident	Conifer/ SF[2]	Uncommon	Declining BBS
Burrowing Owl	**Valley (historical?)**	**Other Migrant**	**Grassland**	**Rare**	**State Sensitive**
Cedar Waxwing	Cascades/ valley	Resident	Edge	Common	Declining BBS
Chestnut-backed Chickadee	Cascades	Resident	Conifer/ SF[2]	Uncommon	Declining BBS
Chipping Sparrow	Cascades/ Valley	Resident	Grassland/ Oak	Very Common	Declining BBS
Common Goldeneye	Valley	Other Migrant	Water	Straggler	Declining BBS[3]
Common Nighthawk	**Cascades/ valley**	**Neotropical Migrant**	**Grassland**	**Common**	**State Sensitive**

Cooper’s Hawk	Cascades/ valley	Resident	Conifer	Uncommon	Declining BBS
Downy Woodpecker	Cascades/ valley	Resident	Riparian/ SF[2]	Uncommon	Declining BBS
Fox Sparrow	Cascades	Basin Migrant	Shrub	Very Common	Declining BBS
Golden Eagle	Winters in valley?	Other Migrant	Grassland	Straggler	Declining BBS[3]
Golden-crowned Kinglet	Cascades	Resident	Conifer	Common	Declining BBS
Grasshopper Sparrow	**Valley**	**Neotropical Migrant**	**Grassland**	**Not noted**	**State Sensitive**
Great Gray Owl	**Cascades**	**Resident**	**Conifer/ Grassland/ SF[2]**	**Uncertain**	**State Sensitive**
Harlequin Duck	**Cascades**	**Other Migrant**	**Water**	**Not noted**	**State Sensitive**
Horned Lark	**Valley**	**Resident**	**Grassland**	**Common**	**State Sensitive**
Killdeer	Valley, Cascades	Resident	Grassland	Abundant	Declining BBS
Lesser Goldfinch	Valley	Resident	Grassland/ Shrub/ SF[2]	Rare	Declining BBS
Lewis' Woodpecker	**Valley**	**Resident**	**Oak/ Riparian/ SF[2]**	**Common**	**State Sensitive**
MacGillivray’s Warbler	Cascades	Neotropical Migrant	Shrub	Common	Declining BBS
Mourning Dove	Valley	Resident	Multiple	Very Common	Declining BBS
Nashville Warbler	Cascades/ valley	Neotropical Migrant	Shrub	Common	Declining BBS
Northern Goshawk	**Cascades**	**Resident**	**Conifer**	**Straggler**	**Decl. BBS, State Sensitive**
Northern Pintail	Valley	Other Migrant	Water	Common	Declining BBS[3]
Northern Pygmy-owl	**Cascades**	**Resident**	**Conifer/ SF[2]**	**Uncertain**	**Decl. BBS, State Sensitive**
Olive-sided Flycatcher	**Cascades**	**Neotropical Migrant**	**Conifer/ Edge**	**Uncommon**	**Decl. BBS, State Sensitive**
Orange-crowned Warbler	Cascades/ valley	Neotropical Migrant	Shrub	Common	Declining BBS
Osprey	Cascades/ valley	Neotropical Migrant	Water/ SF[2]	Uncommon	
Pacific-slope	Cascades/ valley	Neotropical		Common	Declining BBS

Flycatcher		Migrant			
Pileated Woodpecker	**Cascades**	**Resident**	**Conifer/ SF[2]**	**Uncommon**	**Decl. BBS, State Sensitive**
Pine Siskin	Cascades/ valley	Resident	Conifer/ SF[2]	Common	Declining BBS
Purple Finch	Cascades/ valley	Resident	Multiple	Very Common	Declining BBS
Purple Martin	**Cascades/ valley**	**Neotropical Migrant**	**Water/ SF[2]**	**Common**	**Decl. BBS, State Sensitive**
Red-breasted Nuthatch	Cascades/ valley	Resident	Conifer/ SF[2]	Uncommon	Declining BBS
Red-eyed Vireo	Valley	Neotropical Migrant	Riparian	Not noted	Declining BBS
Rufous Hummingbird	Cascades/ valley	Neotropical Migrant	Shrub/ SF[2]	Abundant	Declining BBS
Savannah Sparrow	Valley	Neotropical Migrant	Grassland	Very Common	Declining BBS
Song Sparrow	Cascades/ valley	Resident	Shrub	Abundant	Declining BBS
Spotted Owl	**Cascades**	**Resident**	**Conifer**	**Uncertain**	**Fed. and State Threatend**
Swainson's Thrush	Cascades/ valley	Neotropical Migrant	Conifer	Very Common	Declining BBS
Varied Thrush	Cascades	Resident	Conifer	Very Common	Declining BBS
Vaux's Swift	Cascades/ valley	Neotropical Migrant	Conifer/ SF[2]	Common	Declining BBS
Vesper Sparrow	**Valley**	**Neotropical Migrant**	**Grassland**	**Common**	**State Sensitive**
Violet-green Swallow	Cascades/ valley	Neotropical Migrant	SF[2]	Very Common	Declining BBS
Western Bluebird	**Cascades/ valley**	**Resident**	**Oak/ Grassland/ SF[2]**	**Uncommon**	**State Sensitive**
Western Meadowlark	**Valley**	**Resident**	**Grassland/ SF[2]**	**Very Common**	**Decl. BBS, State Sensitive**
Western Tanager	Cascades/ valley	Neotropical Migrant	Multiple	Common	Declining BBS

Western Wood-pewee	Cascades/ valley	Neotropical Migrant	Multiple	Common	Declining BBS
White-breasted Nuthatch	**Cascades/ valley**	**Resident**	**Oak/ SF[2]**	**Common**	**Declining BBS**
White-crowned Sparrow	Cascades/ winters valley	Basin Migrant	Shrub	Common	Declining BBS
Willow Flycatcher	**Cascades/ valley**	**Neotropical Migrant**	**Riparian**	**Very Common**	**Decl. BBS, State Sensitive**
Wilson's Warbler	Cascades/ valley	Neotropical Migrant	Shrub	Common	Declining BBS
Yellow-billed Cuckoo	**Valley (historical)**	**Neotropical Migrant**	**Riparian**	**Straggler**	**State Sensitive**
Yellow-breasted Chat	**Valley**	**Neotropical Migrant**	**Riparian**	**Very Common**	**State Sensitive**

1) Species listed as using multiple habitats were not strongly associated with a single habitat type; see table B3 for a description of the habitats used by this species.
2) indicates that this species requires some special habitat feature. See table B5 for the habitat feature or features required by this species.
3) Results from Breeding Bird Survey trend analysis within the breeding range of the species (Columbia Plateau for Black-crowned Night Heron and Northern Pintail, British Columbia for Northern Pintail, Common Goldeneye, and Golden Eagle) or from Christmas Bird Survey trend analyses in Oregon.

Appendix 2D: Life history traits of avian Species of Concern in the McKenzie Basin. Information was derived from Csuti et al. (1997) unless otherwise noted.

Species	Life history traits/ important habitats
Acorn Woodpecker	Breeds only in open oak woodlands. Colonial species, living in groups of 2-16 birds with only 1 pair actively breeding. Forage for acorns; require dead limbs or trees for acorn storage. Requires dead limbs or natural cavities for nesting.
American Crow	Nests in trees, but forages in open areas. Avoids dense coniferous forests.
American Goldfinch	Typically use brushy thickets adjacent to weedy fields, pastures, croplands, edges of marshes, or other open areas in the valley. Prefer willow riparian woodlands. Feeds mostly on the seeds of a variety of *Aster* species. Defends an area about 100 ft around the nest.
American Kestrel	Occur in grasslands, open oak woodlands, meadows, and clear-cuts in forests. Nest in woodpecker holes, natural cavities, or nest boxes. Forage mainly on insects and occasionally on small mammals, birds, lizards, snakes, frogs, and earthworms. Territory size ranges from 109 and 130 hectares.
American Robin	Occurs in a variety of habitats including forested and urban areas. Nests in trees or on other level structures such as buildings. Territory size = 0.5 to “several” acres.
Bald Eagle	Primarily nests in forested areas along rivers, lakes, and reservoirs. Typically nests within 1 mi. of water. Typically builds nest in a live tree that are typically older trees with large limbs. Areas that receive little to no human disturbance are important for nesting and foraging success. (Marshall et al. in prep.)
Band-tailed Pigeon	Inhabits coniferous forests. Habitat components identified as important for reproducing Band-tailed Pigeons include: 1) closed-canopy forest for nest sites, 2) open-canopy forests for foraging, and 3) mineral sites. Highly mobile; breeding home range averages 27,482 ac.; may travel 32.1 miles (51.6 km) from nest locations to food or mineral. In the c. Oregon Coast Range, abundant up to 23 mi (37 km) from the nearest known mineral site (Sanders 1999). Nest primarily in Douglas-fir, occasionally in hardwoods and shrubs, within closed-canopy conifer or mixed hardwood and conifer forest stands. Diet includes buds, flowers, and fruits of deciduous trees and shrubs, especially oak, madrone, elder, cherry, cascara, huckleberry, and blackberry. In w. Oregon, 65 known “mineral sites” are currently used: 33 springs, 22 estuaries, 5 dry sites, 3 wastewater sites, and 2 livestock salting areas. (Marshall et al. in prep.)
Barn Swallow	Occurs in open forests and woodlands, grasslands, pastures, agriculture areas. Marshes, lakes, rivers, and urban areas. Require a protected, vertical, surface and nearby sources of mud for nest building. Forage in open areas near nest.
Belted Kingfisher	Found near rivers and lakes. Nests by building a burrow into an embankment. Territories are usually spaced ½ to 2 miles apart. Usually forage within a mile of their nest.
Black-capped Chickadee	Most abundant in hardwood-dominated forests; also occurs in mixed conifer-hardwood forests. Nest in dead trees or dead portions of trees. Typically excavate their own cavities, thus they require well-decayed snags. Forages amongst the foliage of deciduous trees. Territory size = 5-20 acres.
Black-crowned Night Heron	Winters in the W. Valley. Wintering habitats is restricted to areas with standing, shallow water. (JMW)

Black Swift	Nest near or behind waterfalls. Critical factors for nest locations in other states appear to be 1) temperature moderation due to dripping water and little or no direct solar exposure, and 2) high humidity to help attach nest to substrate, vs. elevation or surrounding vegetation type. Feed on the wing above both forested and open areas. Possible nesting locations are noted both north and south of the McKenzie Basin. (Marshall et al. in prep.)
Brewer's Blackbird	Nests in marshes, willow riparian areas, agriculture fields, urban areas, mountain meadows, and cleared or burned areas. Typically prefers to nest near water. Avoids dense interior coniferous forests. Defends the area immediately around the nest.
Brown Creeper	Present in dense, coniferous and deciduous forests. Most abundant in late seral stages. Nests under flaking bark of recently dead trees. Forages on the bole of trees with deeply furrowed bark. (Marshall et al. in prep.)
Burrowing Owl	Irregular winter visitor in valley grassland habitats. Usually found in roadside ditches near culverts, which are probably used for roosting. (Marshall et al. in prep.)
Cedar Waxwing	Found on edges of coniferous, mixed conifer-hardwood, and deciduous forests and woodlands. Forage mostly on berries, but also eats insects in summer and tree sap in winter. Often breed in small colonies with many birds nesting in the same tree. Defend only small area around the nest. Ornamental shrubs in residential areas may be an important food source in winter.
Chestnut-backed Chickadee	Present in all ages of conifer-dominated forests, but most abundant in older coniferous forests. Absent from pure hardwood forests, but may occur in mixed conifer-hardwood forests. Nest in large diameter, well decayed snags. Forages amongst the branches of coniferous trees. (Marshall et al. in prep.)
Chipping Sparrow	Found in open conifer woodlands and at edges of meadows and forest clearings. Forage in bare areas or areas with short grass cover. Territory size 3-7 acres.
Common Goldeneye	Uncommon winter visitant in the W. Valley. Requires open water. (Marshall et al. in prep.)
Common Nighthawk	Nests on bare ground and forages over a variety of habitats. Breeding home range is less than 1square mile.
Cooper's Hawk	Nests in coniferous, mixed, and deciduous forests, as well as riparian, juniper, and oak woodlands. Nests in NW Oregon were located in forests 30-60-yrs old with surrounding tree densities of 265 trees/acre. (Marshall et al. in prep.)
Downy Woodpecker	Lives in hardwood-dominate forests, but also may use mixed conifer-hardwood forests. Often found in suburbs and city parks. Nests in dead or dying trees. Forages on live and dead trees by gleaning or excavating (but a weak excavator) for insects. Territory size usually less than 10 acres. Requires snags or dead limbs for nesting.
Fox Sparrow	Requires thick, scrubby vegetation. Occurs in riparian areas along rivers, in forests and clearings, and at forest edges. Breeds in the Cascade Range; Birds from the North winter in the valley.
Golden Eagle	May winter in the valley in open, grassy habitats.
Golden-crowned Kinglet	Found in dense, coniferous forests. Nests and forages amongst the branches of conifer trees. More abundant in older seral stages and closed-canopy forests than in younger or more open forests. Territory size is about 5 acres.
Grasshopper Sparrow	Reported as occurring in the Willamette Valley during the breeding season. Occurred on lightly grazed pastures and fallow fields dominated by grass < 46 cm. High, little bare ground, and little shrub cover (Altman 2000).

Great Gray Owl	Nests on the top or in cavities of large snags, or in abandoned corvid or squirrel nests. Forages in open areas such as meadows and clearcuts. Found in mixed coniferous and lodgepole pine forests. Most frequently found on north-facing slopes in old-growth forests.
Horned Lark	Nests where there is little to no vegetation, including agricultural areas, pastures, and grasslands.
Harlequin Duck	All information below refers to breeding sites in the W. Cascades, including the McKenzie Basin. Breed on low to moderate gradient (1-7%) 3rd- to 5th-order streams, typically with simple channel morphology and abundant in-stream rocks. Most observations occurred in reaches containing bedrock, boulder and cobble substrates, usually where riffle and glide channel units are present. Nesting occurred along 1st- through 5th-order streams in a variety of seral stages and forest stand characteristics. Horizontal distance from nest to water ranged from 1-82.5 ft (0.3-25 m) for all nests. Feed on stream invertebrates. (Marshall et al. in prep.)
Killdeer	Breed in open areas with short grass cover including pastures, rangeland, shores of lakes or rivers, and agricultural areas. Usually near water. The S. Willamette Valley is a major wintering area.
Lesser Goldfinch	Occurs in fields, pastures, and urban areas with scattered trees or shrubs and usually near water (within ½ mile). Avoids dense conifer forests and is absent from higher elevations. Feed mostly on seeds, even in summer. May nest in small colonies.
Lewis' Woodpecker	Historically an abundant species the valley and Cascades. Nested in open oak woodlands, severely burned-areas, cottonwood woodlands, and other open forest types. Often nests in cavities abandoned by other woodpeckers. Forages by flycatching. (Csuti 1997, Gabrielson and Jewett 1970)
MacGillivray's Warbler	Breeds in brush areas including regenerating clearcuts and burns, forest edges, and understory habitats in open forests. Forages close to the ground in dense shrubs.
Mourning Dove	Found in agricultural lands, pastures, woodlands, and urban areas in the W. Valley. Feed on seed from herbs and shrubs. Nests built of twigs and usually placed high in a tree. Defends a small territory around nest and feed up to 3 mi. from nest.
Nashville Warbler	Breeds in brush areas including regenerating clearcuts and burns, forest edges, and understory habitats in open forests.
Northern Goshawk	Foraging areas typically 4900-5900 ac, comprised of a forest mosaic including large trees, snags, and downed logs interspersed with openings. Heavy shrub layers believed to inhibit goshawk foraging. Nests typically built in one of the largest trees within 20-39 acre dense patches of large old trees. Nest sites can have single layer or multi-layered canopies. Common nest site characteristics are Mature stands with a high basal area of large trees, high canopy closure, an open understory, on moderate slopes, and often close to perennial water. (Marshall et al. in prep.)
Northern Pintail	Migrates through and winters in the W. Valley. Migration and wintering habitat includes open, shallow wetlands, flooded agricultural fields, and shallow areas of larger lakes. (Marshall et al. in prep.)
Northern Pygmy-owl	Nests in abandoned woodpecker or natural cavities in dead trees. Most common in contiguous tracts of coniferous forest, but also will occur in fragmented forests. Most commonly detected in tall, mature conifer forests. Rarely detected in isolated riparian areas, small woodlots and early seral forest. May prefer forests with a complex overstory and little understory. (Marshall et al. in prep.)

Olive-sided Flycatcher	Prefers forested areas with an uneven canopy. Preferred habitats include areas within forest burns where snags and scattered tall, live trees remain; near water along wooded shores of streams, lakes, rivers, beaver ponds, marshes, and bogs, often where standing dead trees are present; at the juxtaposition of late- and early-successional forest such as meadows, harvest units, or canyon edges; and in open or semi-open forest stands with a low percentage of canopy cover. Tall snags and logs (relative to surrounding areas) are important features of breeding habitat. (Marshall et al. in prep.)
Orange-crowned Warbler	Breeding habitat characteristically includes brushy areas, particularly deciduous growth and riparian thickets. Forages on a variety of substrates (shrubs, conifers, hardwoods), but deciduous plants may be particularly important. (Marshall et al. in prep.)
Osprey	Nests within 2 mi. of bodies of water that support fish. Need clear water for foraging. Require broken-top live trees, snags, or utility poles for nesting. (Marshall et al. in prep.)
Pacific-slope Flycatcher	Breeds in all types of forested habitats up to 4,000 ft. elevation. Forages low in the canopy.
Pileated Woodpecker	Nests in large-diameter snags (mean dbh in Coast Range 27") in late seral coniferous forests. Tall snags are needed; nest cavities excavated at a mean height of 50 ft. Forages on large-diameter logs. (Marshall et al. in prep.)
Pine Siskin	Occurs in coniferous forests; most abundant in older coniferous forests. Nests in loose colonies.
Purple Finch	Prefers open areas and edges of coniferous forests. Also use edges in mixed conifer-hardwood forests. Absent from interior of dense forests. Nests high in conifer trees; forage mostly on insects amongst branches of trees in summer and on seeds in winter. Ash seeds are an important item in their diet.
Purple Martin	Forages over open areas such as rivers, lakes, marshes, fields, and high above the canopy of forests. Nests in cavities in open habitats. Oregon nest sites include snags in forest clearcuts and burns, snags in coastal dunes, old pilings and nestboxes along estuaries and rivers, gourds set on poles in fields, and crevices beneath docks and bridges. May prefer to nest near or directly over water, but nesting sites have been located as far as 3 mi. from water. (Marshall et al. in prep.)
Red-breasted Nuthatch	Present in coniferous and conifer-hardwood forests. Rare in pure hardwood stands. Typically more abundant in older seral stages. Nests in dead trees. Forages amongst the branches and on the bole of trees. Feeds on conifer seeds in winter. (Marshall et al. in prep.)
Red-eyed Vireo	Associated with cottonwood, alder, and willow riparian woodlands and gallery forests. Also uses Oregon Ash (Csuti et al. 1997). Historically occurred in Lane County, near Oakridge (Gabrielson and Jewett 1970).
Rufous Hummingbird	Prefers wooded areas with a tall canopy and a well-developed understory. Builds nest low among the branches of conifers. Forage on nectivorous plants, especially red currant, salmonberry, paintbrushes, columbine, and penstemons. (Marshall et al. in prep.)
Savannah Sparrow	Breeds in grasslands, pastures, agricultural areas, wet prairies, mountain meadows, and in grassy areas surrounding lakes, ponds, and rivers. Territory size is less than 1 acre.
Song Sparrow	Requires thickets of deciduous shrubs. Often found in willows in riparian areas, and around marshes, lakes, and ponds. Territory size is <= 1 acre.
Spotted Owl	Occurs in coniferous forest; most abundant in old-growth and mature forests. In younger forests, it is often associated with residual older trees. Nests in large cavities or on platforms of trees or snags. Usually nests in large trees. Home range is 3,000-4,500 acres. Normally resides on its breeding territory year round. (Marshall et al. in prep.)

Swainson's Thrush	Breeds in dense Douglas-fir forests and in riparian areas. Forage on the ground for insects or on shrubs for berries.
Varied Thrush	Most abundant in dense, older coniferous forests. Feed on a variety of plants and insects.
Vaux's Swift	Nests in large-diameter snags in coniferous forests. More abundant in older forests than in younger forests. Forages over forest canopies, water, and grasslands. (Marshall et al. in prep.)
Vesper Sparrow	General nesting habitat requirements include elevated perches for singing and a grass-dominated understory for foraging and nesting. In the Willamette Valley, primarily associated lightly grazed pastures with scattered shrubs and short grasses and Christmas tree farms, particularly young farms 2-5 yrs post-planting, if extensive grasses and weeds are present. Only rarely encountered in grass-seed fields. Mean territory size 3.1 ac. Nesting pairs occurred in small areas of habitat (<10 ac [4 ha]) in Willamette Valley, thus small blocks of suitable habitat (e.g., 10-20 ac) may provide for a few pairs regardless of surrounding habitat. Nests placed on ground, often against clump of vegetation, crop residue, clod of dirt, or at base of shrub or small tree (BA). Nest success in Christmas tree farms dependent upon low degree of activity (e.g., herbaceous vegetation control, tree pruning, and recreation) during breeding season (Altman 1999c). Found in grasslands of the Coburg Ridge (Altman, pers. comm.; Marshall et al. in prep.)
Violet-green Swallow	Nests in cavities near agricultural areas, urban areas, and very open forests. Forages over clearings such as meadows and open water.
Western Bluebird	Nests in meadows, grasslands abutting forest, oak savannah; mixed coniferous transition zones; deciduous open woodland with sparse understory; and early succession clearcuts. Snags used for nesting in Coast Range study (n=18) averaged 28 in (71 cm) dbh, range 9.8- 53.9 in (25-137 cm); 30.2 ft (9.2 m) in height, range 11.8-59.1 ft (3.6-18.0 m). Requires snags or boxes for nesting. Forages by flycatching or on the ground. Home range is 1 to several acres. Competition for nest sites with European Starlings is of particular concern. (Csuti 1997, Marshall et al. in prep.)
Western Meadowlark	Has the most significant declining populations of all of the avian Species of Concern; near extirpation from the Willamette Valley. Optimal breeding habitat in Willamette Valley is lightly grazed pastures or fallow fields with grass height 1-2 ft (0.3-0.6 m), and shrub or tree cover <10%. Marginal habitat is hayfields and cultivated grass fields (annual or perennial) with grass height 1-3 ft (0.3-1 m) and shrub or tree cover <25%. Cultivated grass fields used as escape cover and to a lesser extent nesting cover, but only limited use as foraging habitat. Thus, quality foraging habitat (e.g., lightly grazed pastures, fallow fields) needs to be adjacent to or within territories dominated by cultivated grass fields or hayfields for the latter habitats to be used for nesting. Singing perches (fence-lines, telephone pole, shrubs, trees) are essential components of all territories. Territory size is typically 10-19 acres. (Marshall et al. in prep.)
Western Tanager	Breeds in coniferous and mixed conifer-hardwood forests and in oak woodlands.
Western Wood-pewee	Breeds in many different types of forested habitats, including open coniferous stands, along forest edges, and in deciduous and mixed conifer-hardwood forests, in oak woodlands, and in riparian areas. Territory size is a few acres.
White-breasted Nuthatch	Present in deciduous forests, especially in oak woodlands. Absent from dense, coniferous forests. Also found in mixed conifer-hardwood forests. Often nests in abandoned woodpecker cavities, sometimes excavates their own cavities. Territory sizes range from 3 to 100 acres.
White-crowned Sparrow	Require brushy thickets for nesting and occur in most habitat-types. Avoid dense forest interiors. Territory = 0.1 to 2 acres.

Willow Flycatcher	Breeds in willows in riparian areas and in forest clearings that have tall, brushy shrubs (i.e., regenerating clearcuts). Territory size = 1-3 acres.
Wilson's Warbler	Breeds in brushy areas within forests, especially in willow or alder thickets at forest edges, near water, or in riparian vegetation. Territory size = 1-3 acres. (Csuti et al. 1997). Abundance is associated with the presence of hardwood shrubs and trees. Rare in dense conifer plantations where shrubs cover is low. (Marshall et al. in prep.)
Yellow-billed Cuckoo	Formally occurred, but was rare, in riparian habitats of the Willamette Valley. Specifically noted as occurring in "willow bottoms of the Willamette River," and "nesting near Sweet Home." (Gabrielson and Jewett 1970)
Yellow-breasted Chat	Breeds in brushy riparian areas. Will use brushy areas in openings or in the understory of hardwood or mixed hardwood-conifer woodlands.

Appendix 2E. Avian migrants likely to occur seasonally in the McKenzie Basin and habitats they use; some species occasionally winter in the Basin (From Csuti et al. 1997).

Species	Habitats
American Avocet	Shallow water, marshes
American Tree Sparrow	Brushy areas, marshes
American White Pelican	Lakes
Black-necked Stilt	Shallow water, marshes
Brant	Open water, fields
Clay-colored Sparrow	Brushy areas
Common Loon	Open water
Ferruginous Hawk	Fields
Greater white-fronted Goose	Open water, fields
Harris's Sparrow	Open woodlands, brushy areas
Horned Grebe	Open water
Horned Lark	Grasslands with short grass and bare areas
Lesser Golden-plover	Shallow water, fields
Lesser Yellowlegs	Shallow water, fields
Long-billed Curlew	Shallow water, fields
Long-eared Owl	Open coniferous and mixed coniferous/deciduous forests
Marbled Godwit	Shallow water, fields
Northern Phalarope	Open water
Red-breasted Merganser	Open, clear, fish-bearing water
Redhead	Open Water
Red-necked Duck	Open water
Ross's Goose	Open water, fields
Semipalmated Plover	Shallow water, fields
Short-billed Dowitcher	Shallow water, fields
Snow Goose	Open water, fields
Swamp Sparrow	Marshes, brushy areas
Whimbrel	Shallow water, fields
Western Sandpiper	Shallow water, fields
White-fronted Goose	Shallow water, fields
White-winged Crossbill	Coniferous forests
Willet	Shallow water, fields
Wilson's Phalarope	Open water

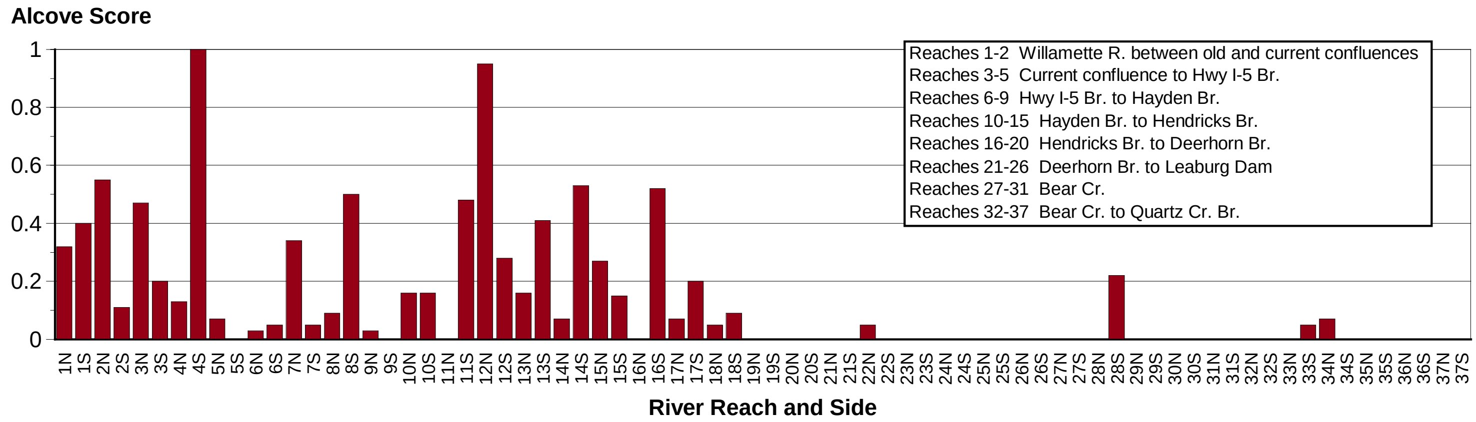
Appendix 2F.
The list of threatened, rare or sensitive vascular plants with documented or possible distribution in the McKenzie River Subbasin. (Derived from the Oregon Natural Heritage Program database. http://ocelot.tnc.org/nhp/)

Common Name	Scientific Name	Ecoregion	Federal Status	ODA Status	ONHP List
green-flowered wild-ginger	*Asarum wagneri* Lu & Mesler	WC	--	C	4
wayside aster	*Aster vialis* (Brads.) Blake	WV, WC	SoC	LT	1
woodland milk-vetch	*Astragalus umbraticus* Sheld.	WC	--	--	4
sedge	*Carex gynodynama* Olney	WC	--	--	3
smooth beaked sedge	*Carex integra* Mkze.	WC	--	--	3
tall bugbane	*Cimicifuga elata* Nutt.	WV, WC	SoC	C	1
Larsen's collomia	Collomia larsenii	WC	--	--	4
mountain lady's-slipper	*Cypripedium montanum* Douglas	WV, WC	--	--	4
cliff paintbrush	*Castilleja rupicola* Piper	WC	--	--	2
golden alpine draba	*Draba aureola* S. Watson	WC	--	--	4
Nuttall's waterweed	Elodea nuttallii (Planchon) H. St. John	WV, WC	--	--	3
Cascade daisy	*Erigeron cascadensis* Heller	WC	--	--	4
Willamette daisy	*Erigeron decumbens* Nutt. var. *decumbens*	WV	LE	LE	1
western wahoo	*Euonymus occidentalis* Torr.	WV, WC	--	--	4
Umpqua swertia	*Frasera umpquaensis* Peck & Appleg.	WC	SoC	C	1
Newberry's gentian	*Gentiana* newberryi A. Gray var. *newberryi*	WC	--	--	2
Bolander's hawkweed	*Hieracium bolanderi* A. Gray	WC	--	--	4
shaggy hawkweed	*Hieracium horridum* Fries	WC	--	--	3
shaggy horkelia	*Horkelia congesta* Douglas ssp. *congesta*	WV	SoC	C	1
thin-leaved peavine	*Lathyrus holochlorus* (Piper) C.L. Hitchc.	WV	--	--	4
Columbia lewisia	*Lewisia columbiana* (How.) Robins. var. *columbiana*	WC	--	--	2
Kincaid's lupine	*Lupinus sulphureus* Douglas ssp. *Kincaidii* (Smith) Phillips	WV	LT	LT	1
bog club-moss	*Lycopodiella* inundata (L.) Holub	WC	--	--	2
stiff club-moss	*Lycopodium annotinum* L.	WC	--	--	4
branching montia	*Montia diffusa* (Nutt.) Creene	WV, WC	--	--	4

Common Name	Scientific Name	Ecoregion	Federal Status	ODA Status	ONHP List
adder's-tongue	*Ophioglossum pusillum* Raf. *(O. vulgatum* L. misapplied*)*	WC	--	--	2
coffee fern	*Pellaea andromedifolia* (Kaulf.) Fee	WV	--	--	2
spring phacelia	*Phacelia verna* How.	WC	--	--	4
loose-flowered bluegrass	*Poa laxiflora* Buckl.	WC	--	--	4
Suksdorf's bluegrass	*Poa suksdorfii* (Beal) Vasey ex Piper	WC	--	--	3
dotted smartweed	*Polygonum puctatum* Elliott	WV	--	--	3
Thompson's mistmaiden	*Romanzoffia thompsonii* Marttala	WV	--	--	1
scheuchzeria	*Scheuchzeria palustris* L. var. *americana* Fern	WC	--	--	2
water clubrush	*Scirpus subterminalis* Torr.	WC	--	--	2
Cusick's checker-mallow	*Sidalcea cusickii* Piper	WV, WC	--	--	4
Suksdorf's silene	*Silene suksdorfii* Robins.	WC	--	--	4
Hichcock's blue-eyed grass	*Sisyrinchium hitchcockii* D. Henderson	WV	--	--	1
Shortfruited smelowskia	*Smelowskia ovalis* M.E. Jones var. *ovalis*	WC	--	--	4
small-flowered trillium	*Trillium parviflorum* Soukup	WV, WC	--	--	3
humped bladderwort	*Utricularia gibba* L.	WV	--	--	2
lesser bladderwort	*Utricularia minor* L.	WC	--	--	2
wild bog cranberry	*Vaccinium oxycoccos L.* = V. o. var. *intermedium*	WC	--	--	4
dotted water-meal	*Wolffia borealis* (Hegelm.) Landolt & O. Wildi	WV	--	--	2

Definitions: *Ecoregion*: WV = Willamette Valley; WC = Western Cascade Range and Crest.
Federal and Orgegon Department of Agriculture Status: LE = Listed as endangered on the federal or state endangered species lists; LT = Listed under federal or state lists as threatened; C = Candidate taxa for which agencies have sufficient information to support a proposal to list under state or federal endangered species acts. SoC = Species of concern. These are species that are being reviewed for consideration as listed species.
Oregon Natural Heritage Program (ONHP) *List Rankings:* 1 = Contains taxa that are threatened with extinction or presumed to be extinct throughout their range; 2 = Contains taxa that are threatened with extirpation or presumed to be extirpated from the state of Oregon; 3 = Contains species for which more information is needed before status can be determined, but which may be threatened or endangered throughout their range; 4 = Contains taxa which are of conservation concern but are not currently threatened or endangered.

Appendix 3
Appendix 3A. Scores for channel habitat quality modeling.



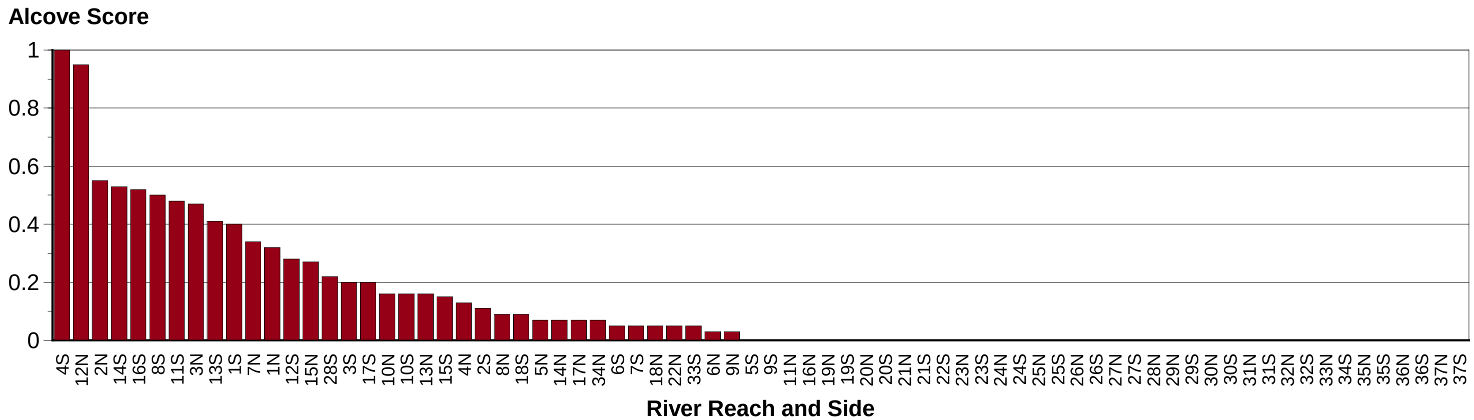
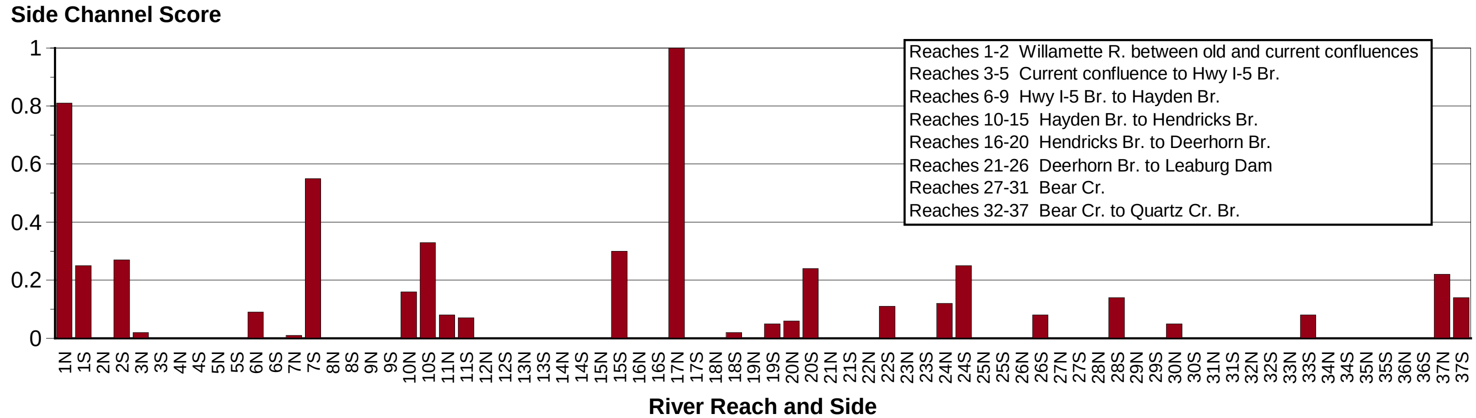


Figure 1. Alcove scores (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



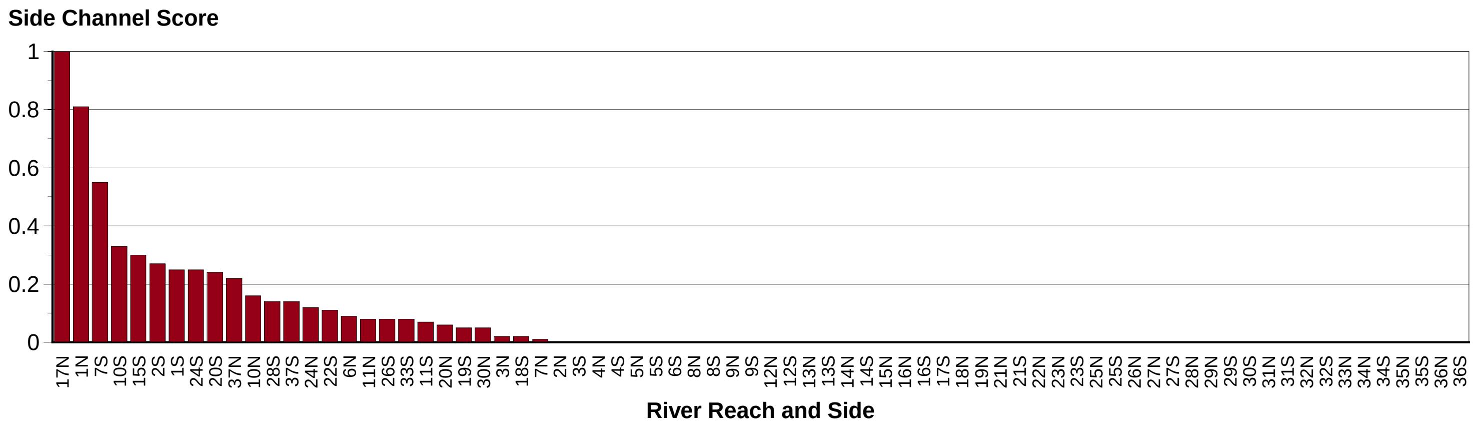
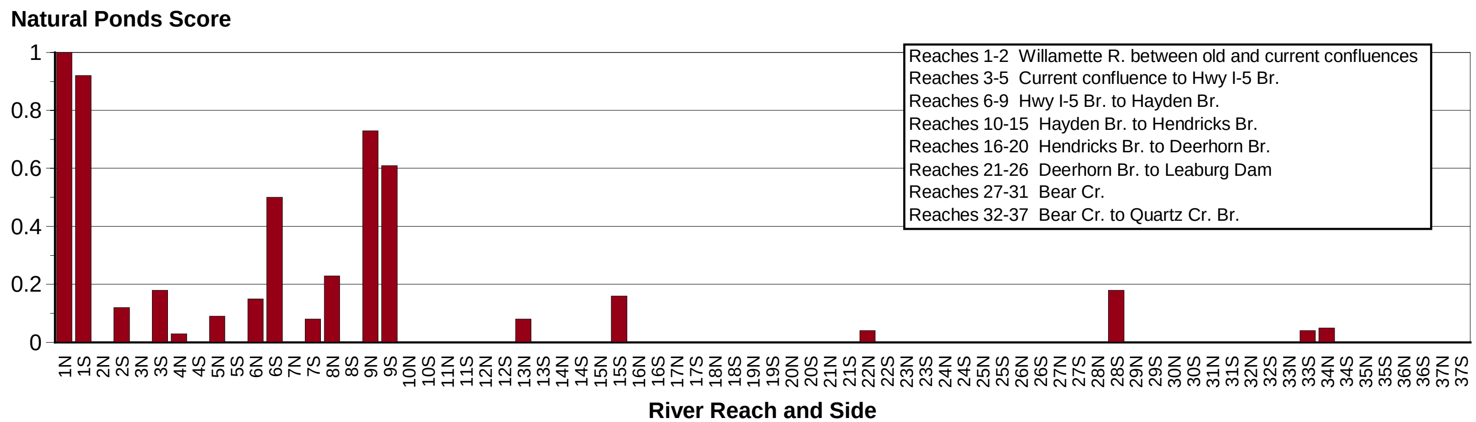


Figure 2. Side channel scores (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



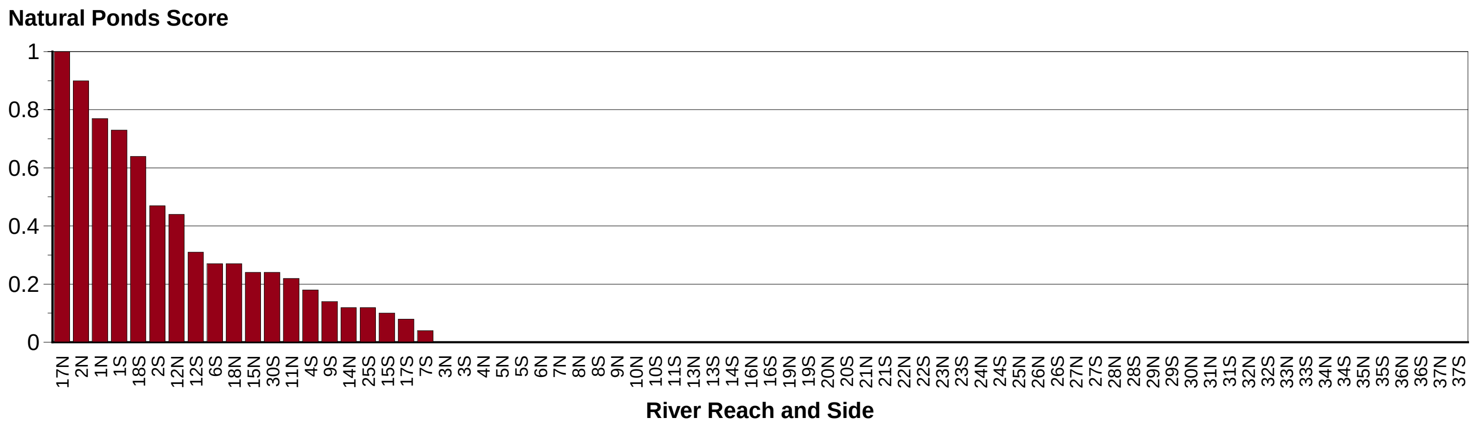
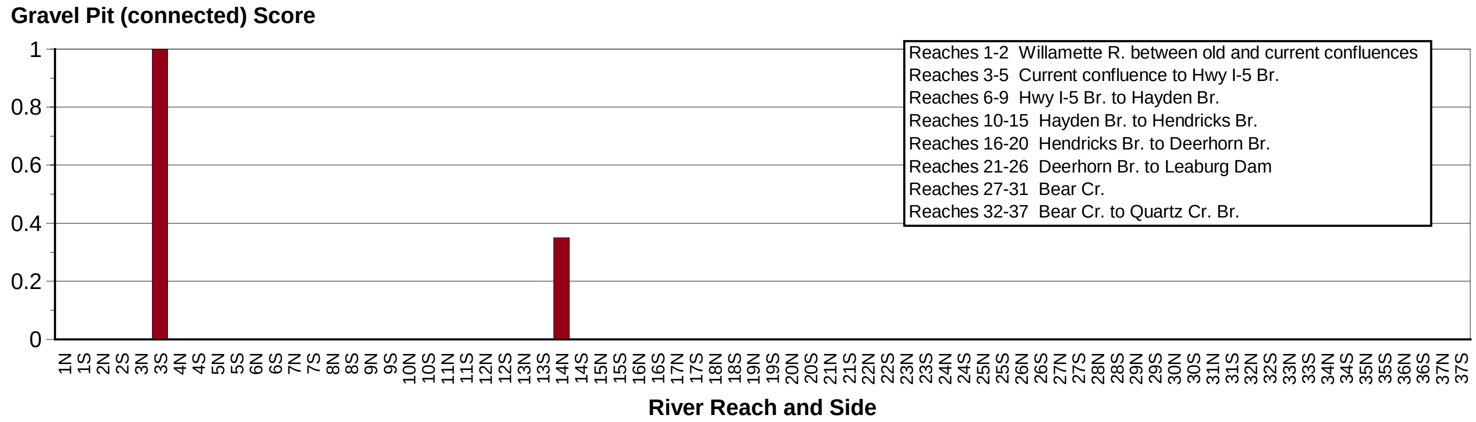


Figure 3. Natural pond scores (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



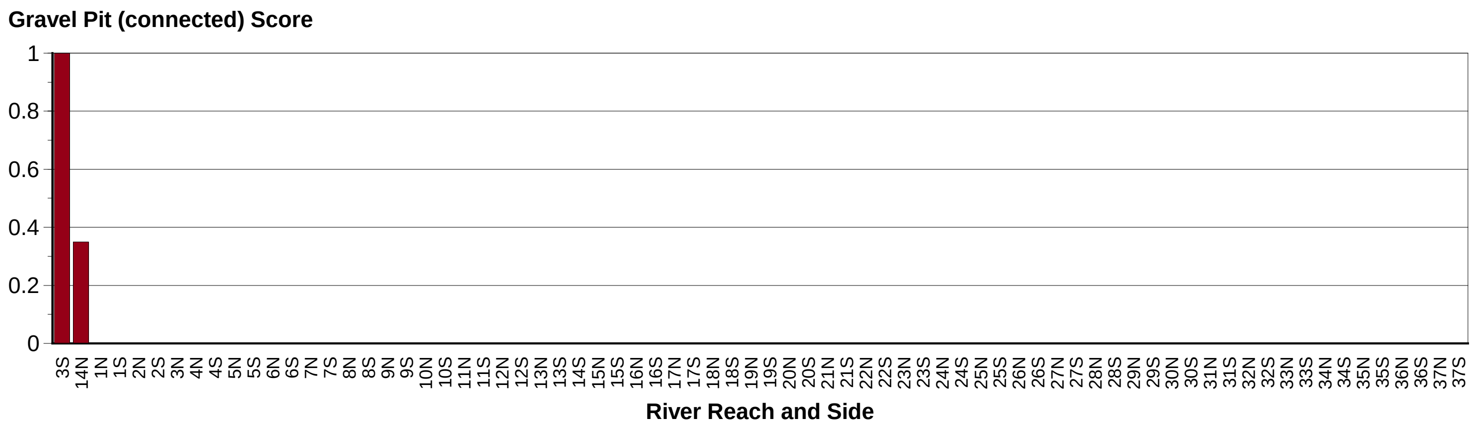


Figure 4. Scores for gravel pits connected to the river (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.

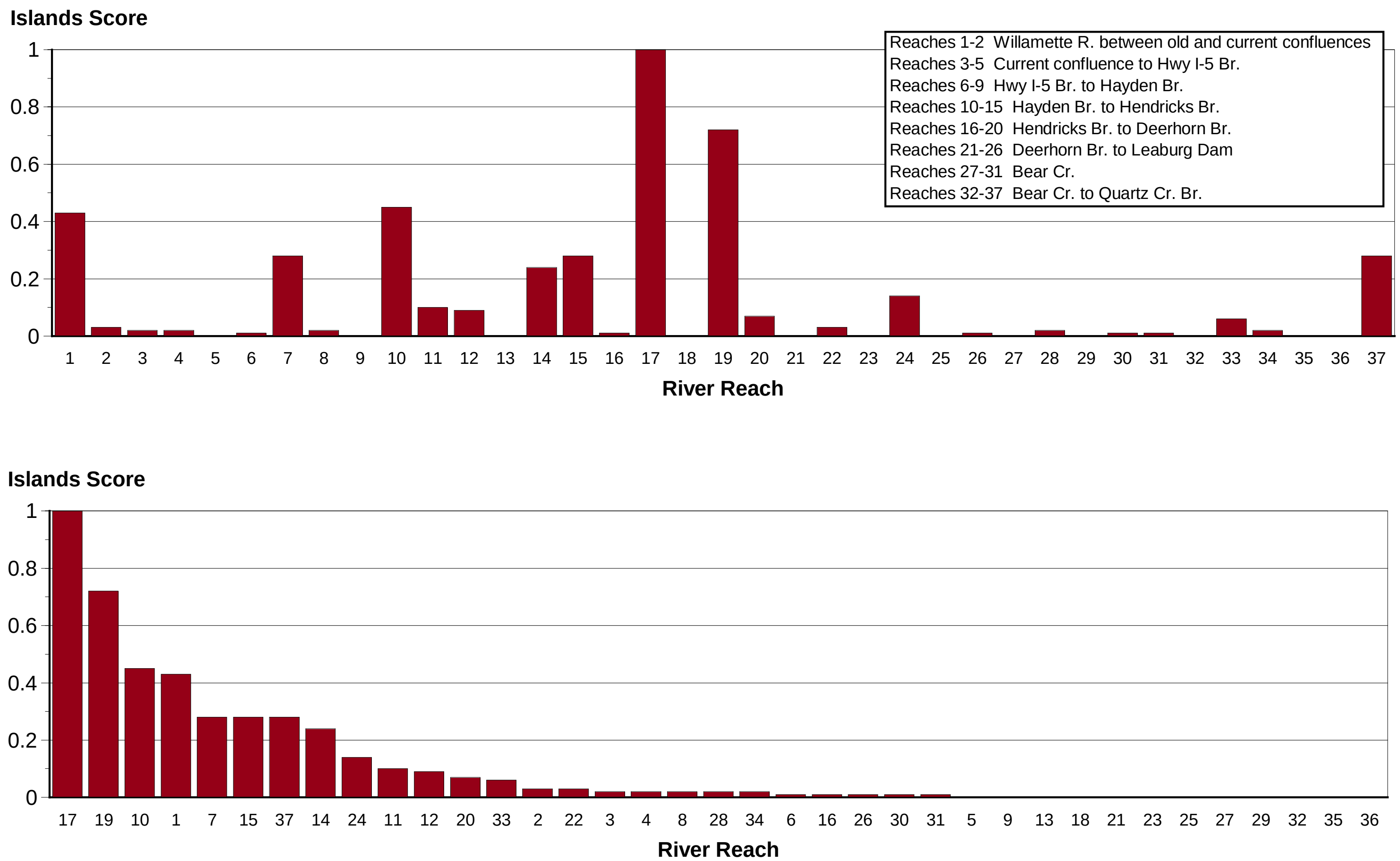


Figure 5. Island scores (standardized values) for 37 reaches. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.

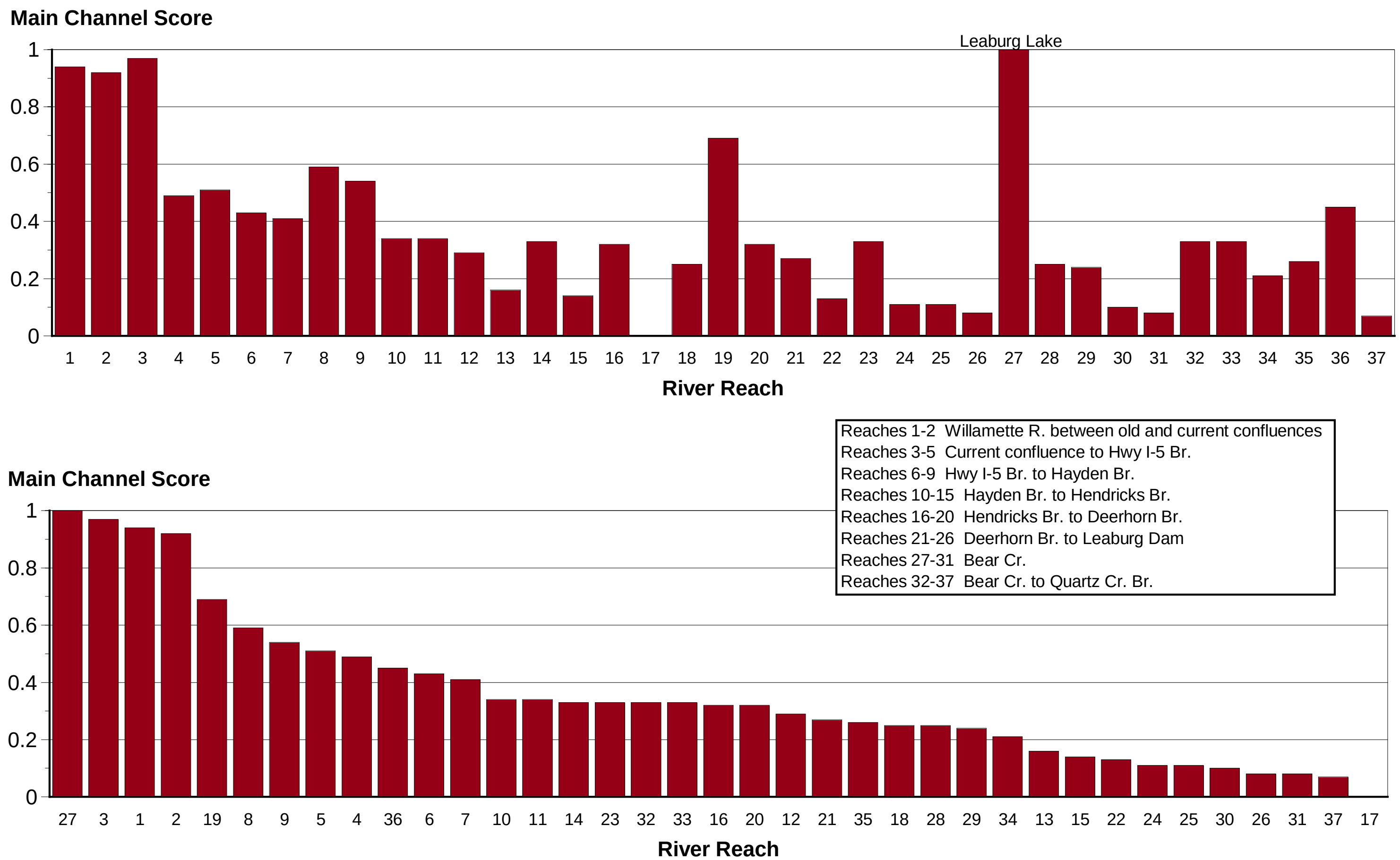
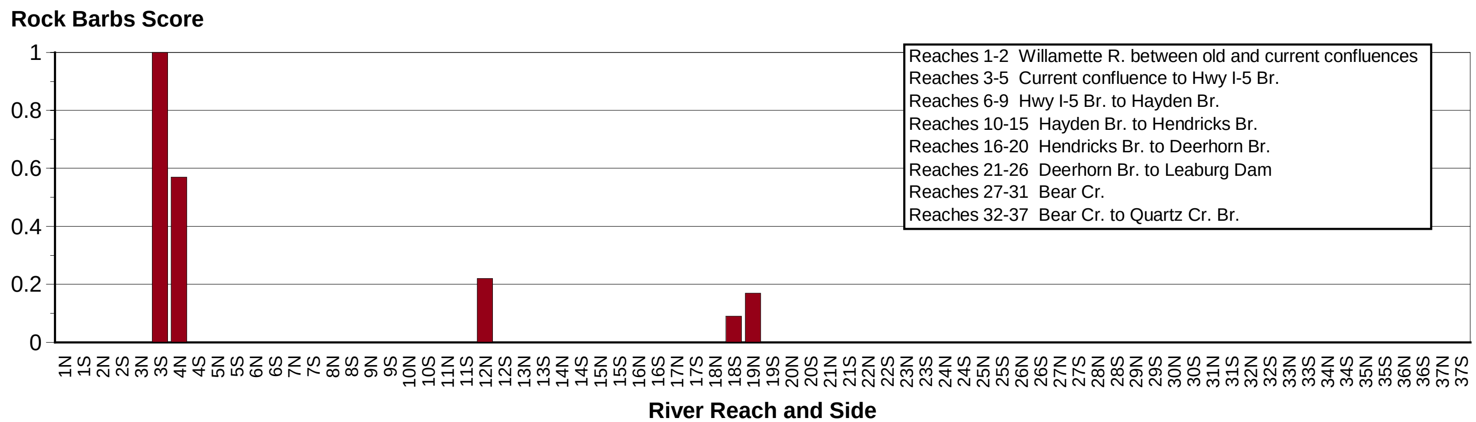


Figure 6. Main channel scores (standardized values) for 37 reaches. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



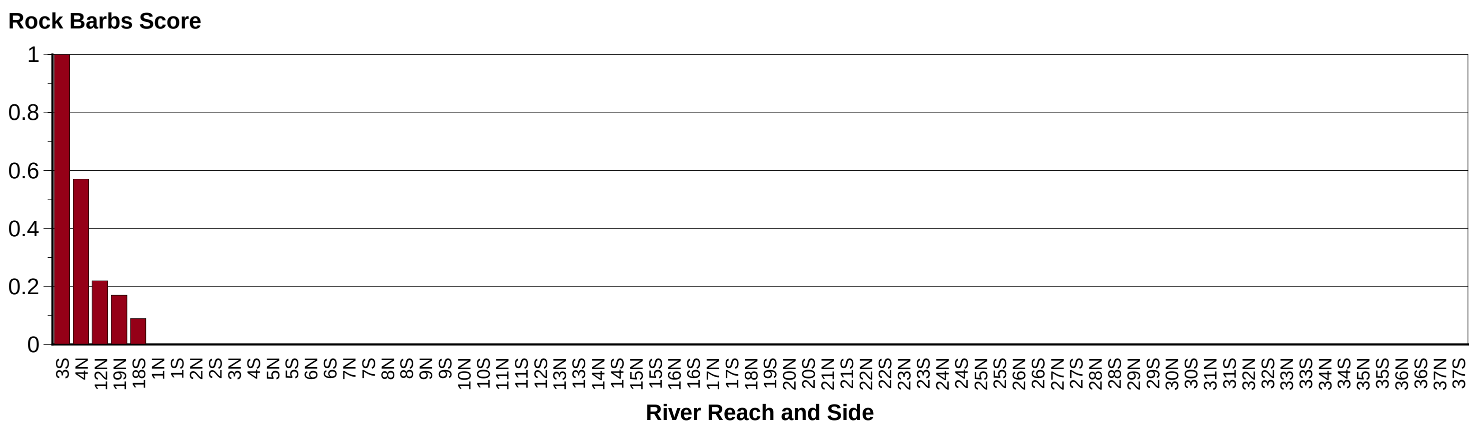


Figure 7. Rock barbs scores (standardized values) for 37 reaches. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.

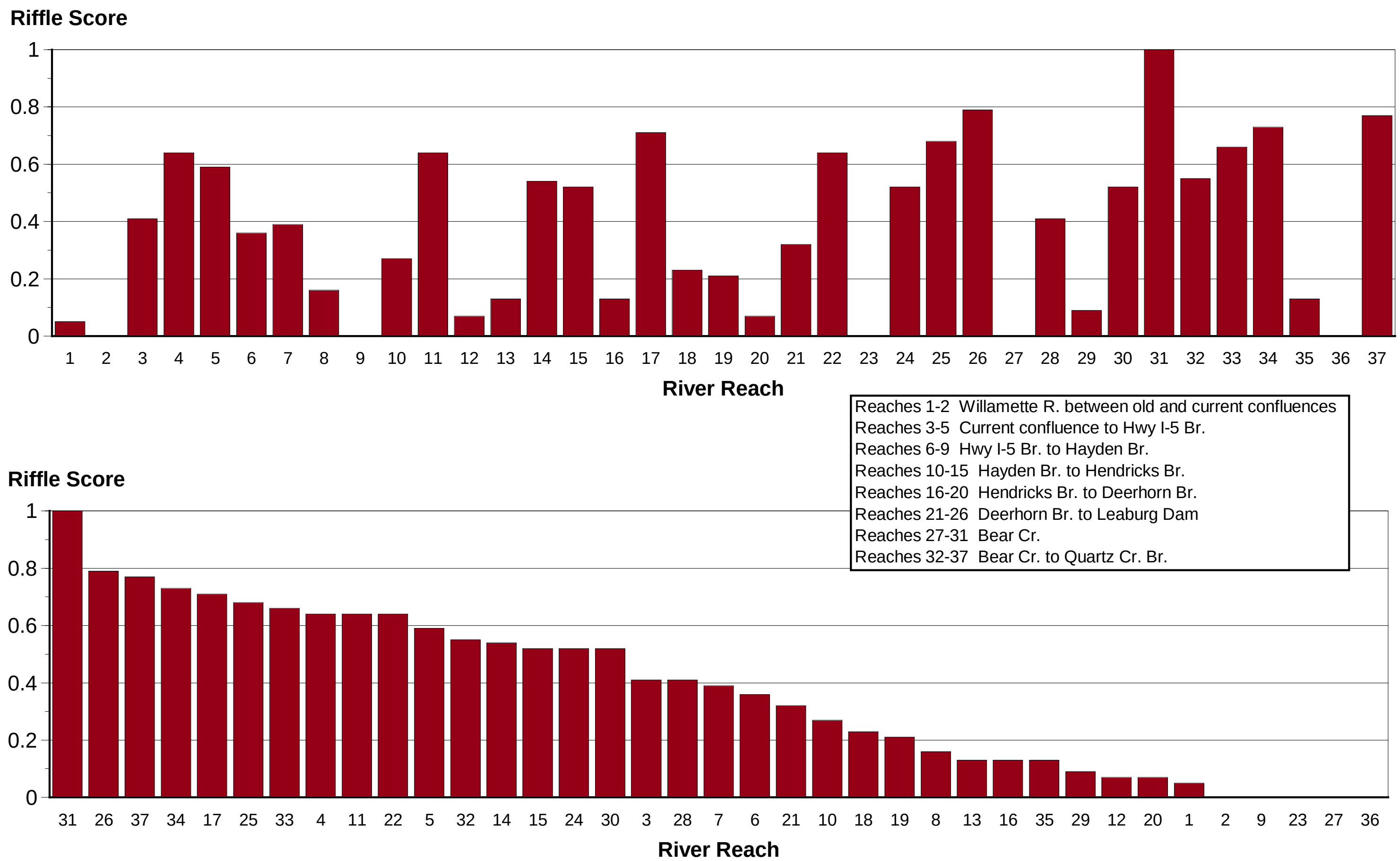
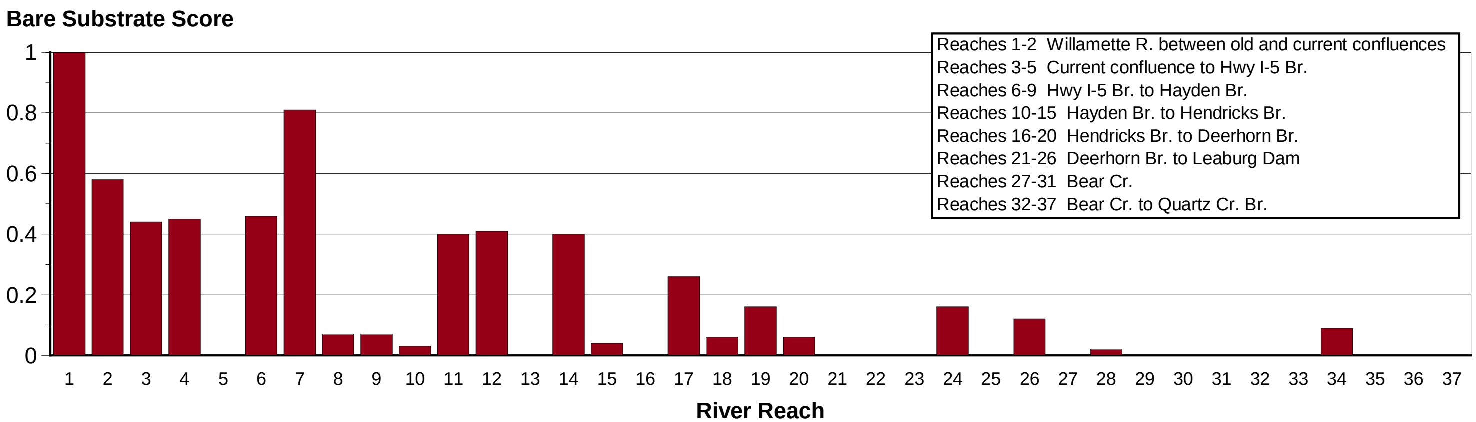


Figure 8. Riffle scores (standardized values) for 37 reaches. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



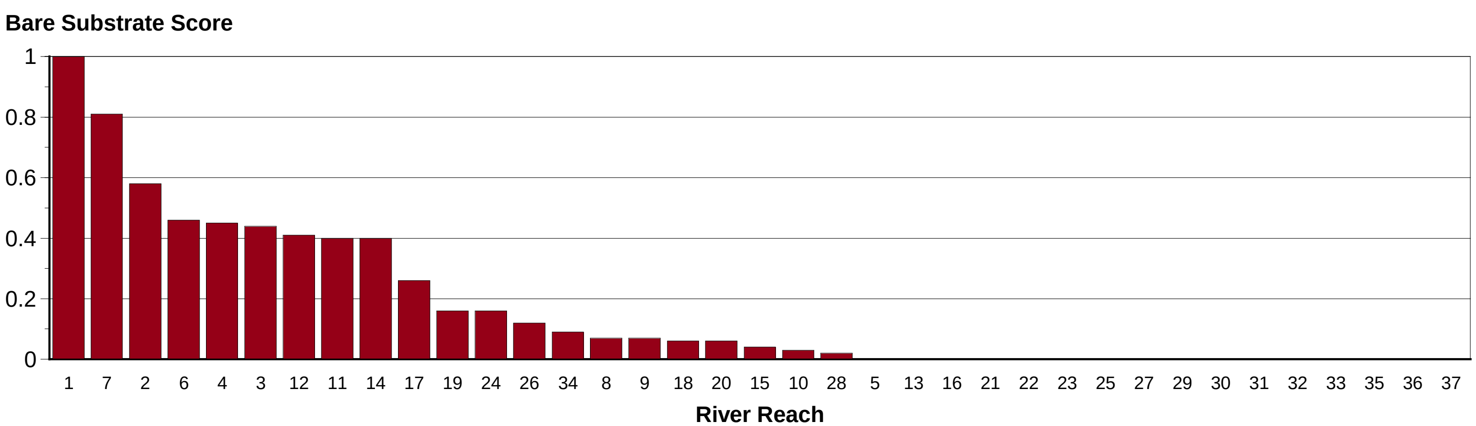
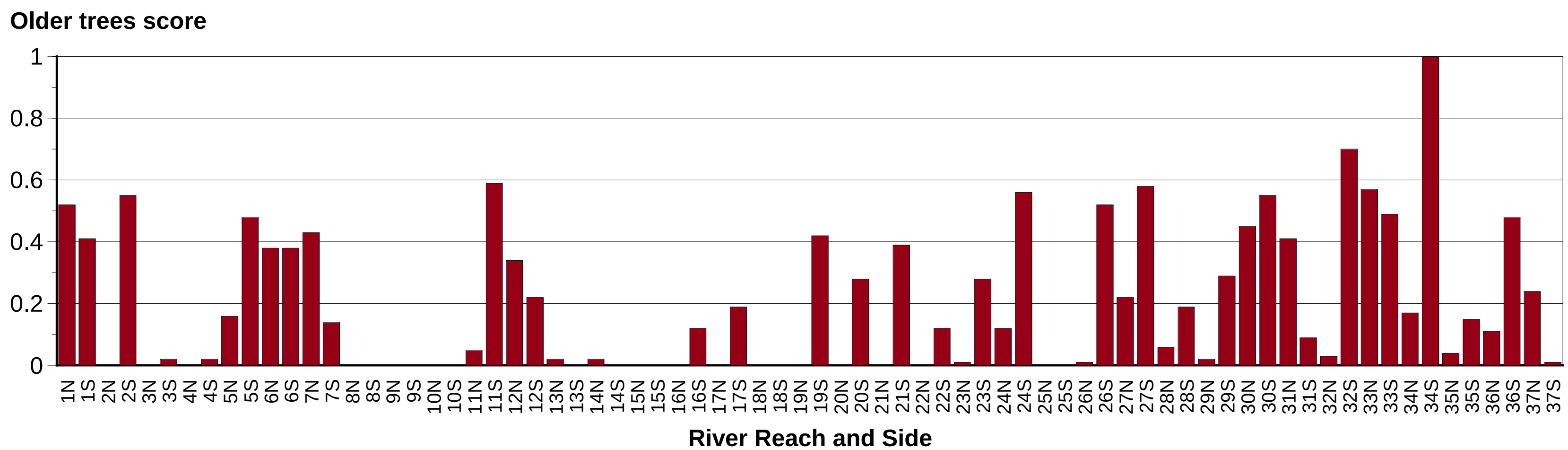


Figure 9. Bare substrate scores (standardized values) for 37 reaches. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



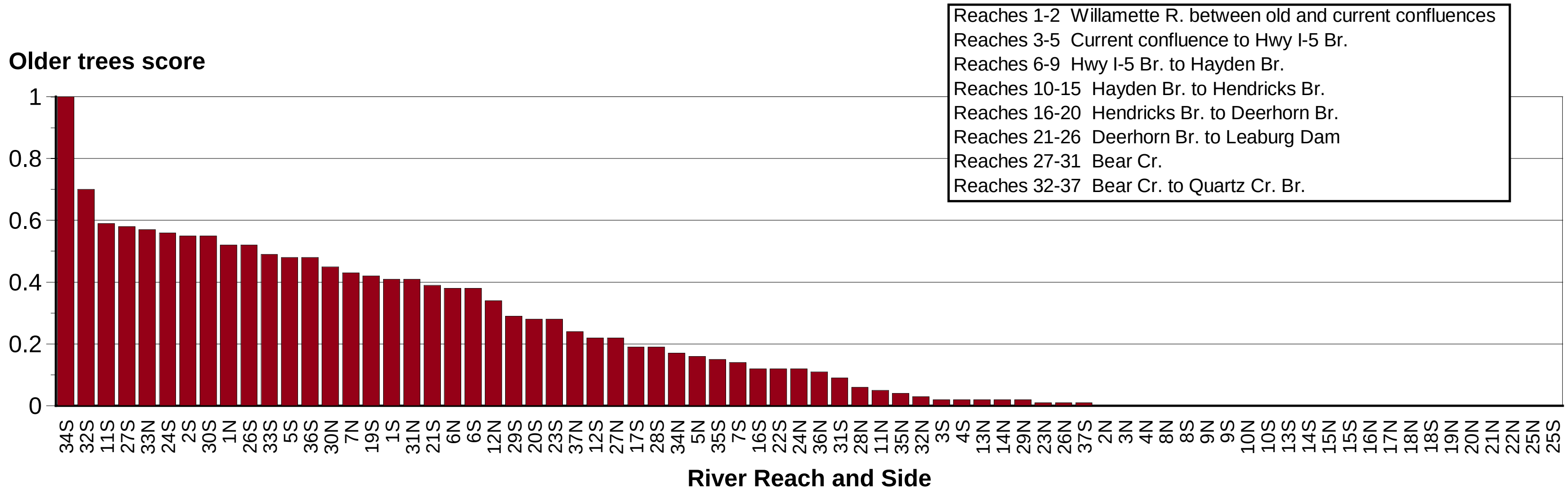
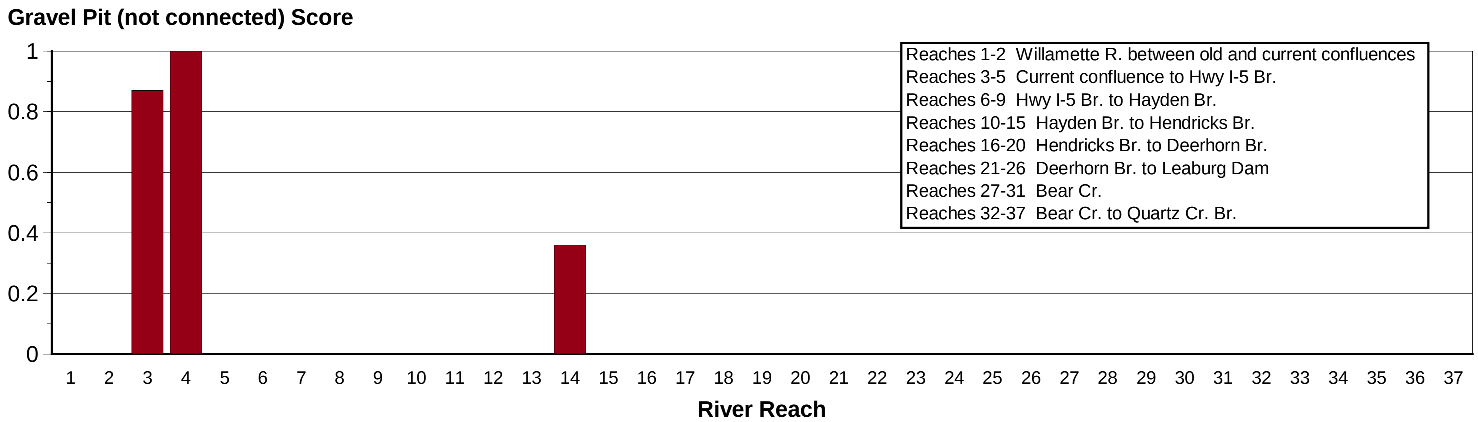


Figure 10. Older trees scores (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



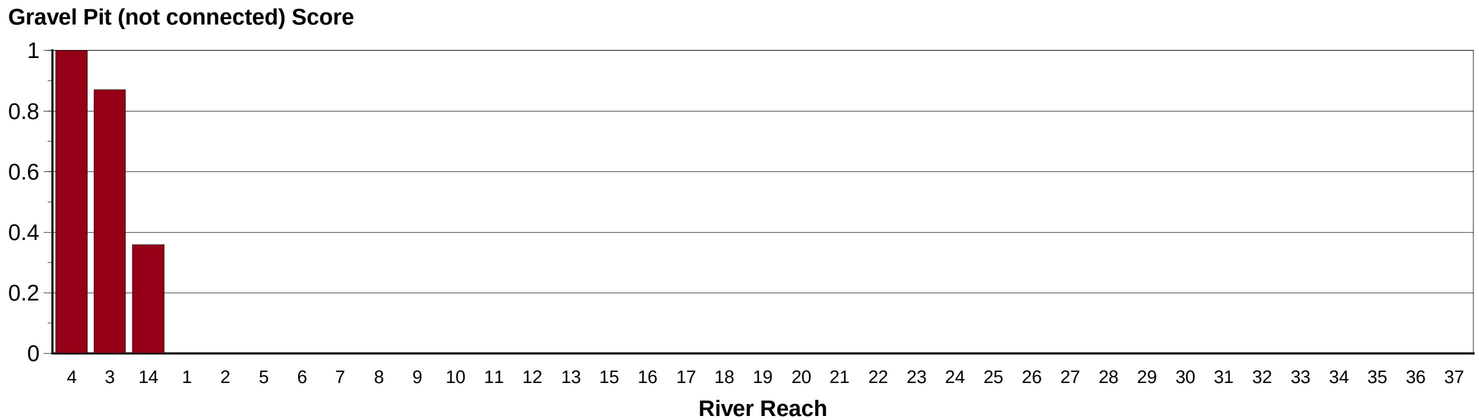
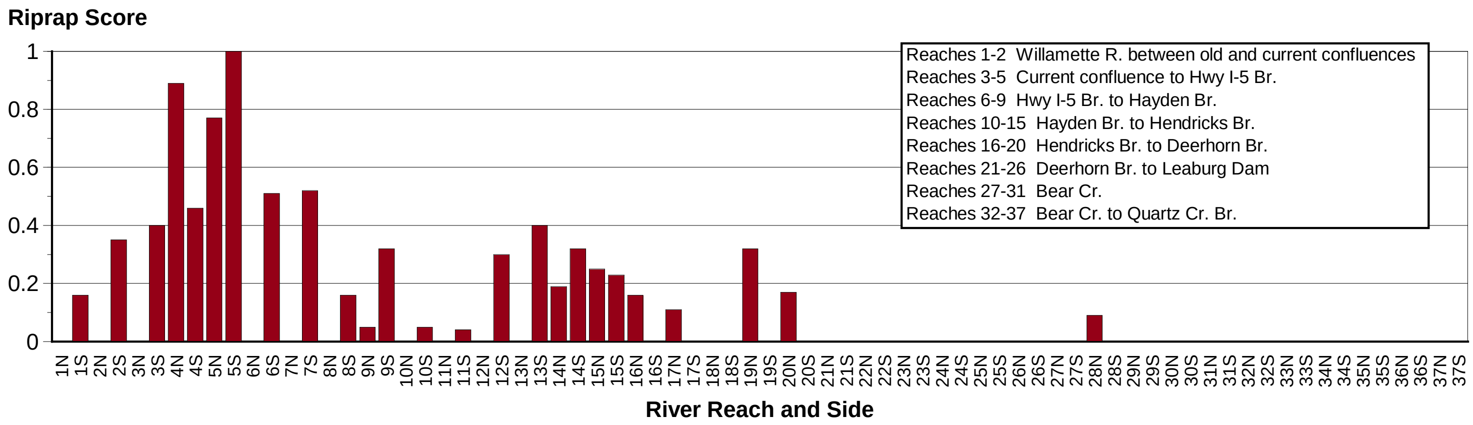


Figure 11. Scores for gravel pits that are not connected with the river (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.



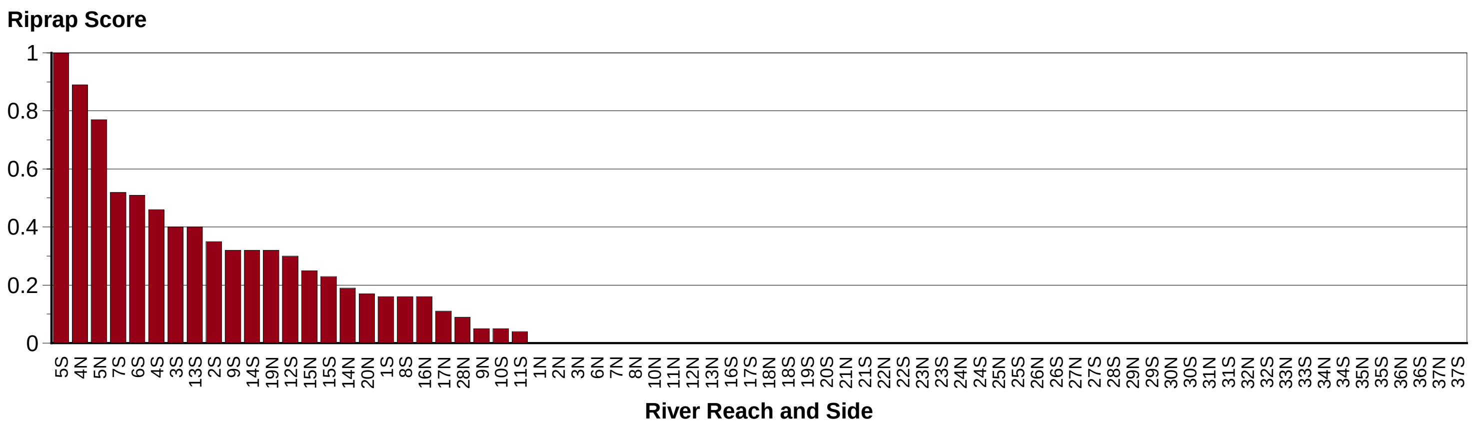


Figure 12. Riprap scores (standardized values) for 37 reaches. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.

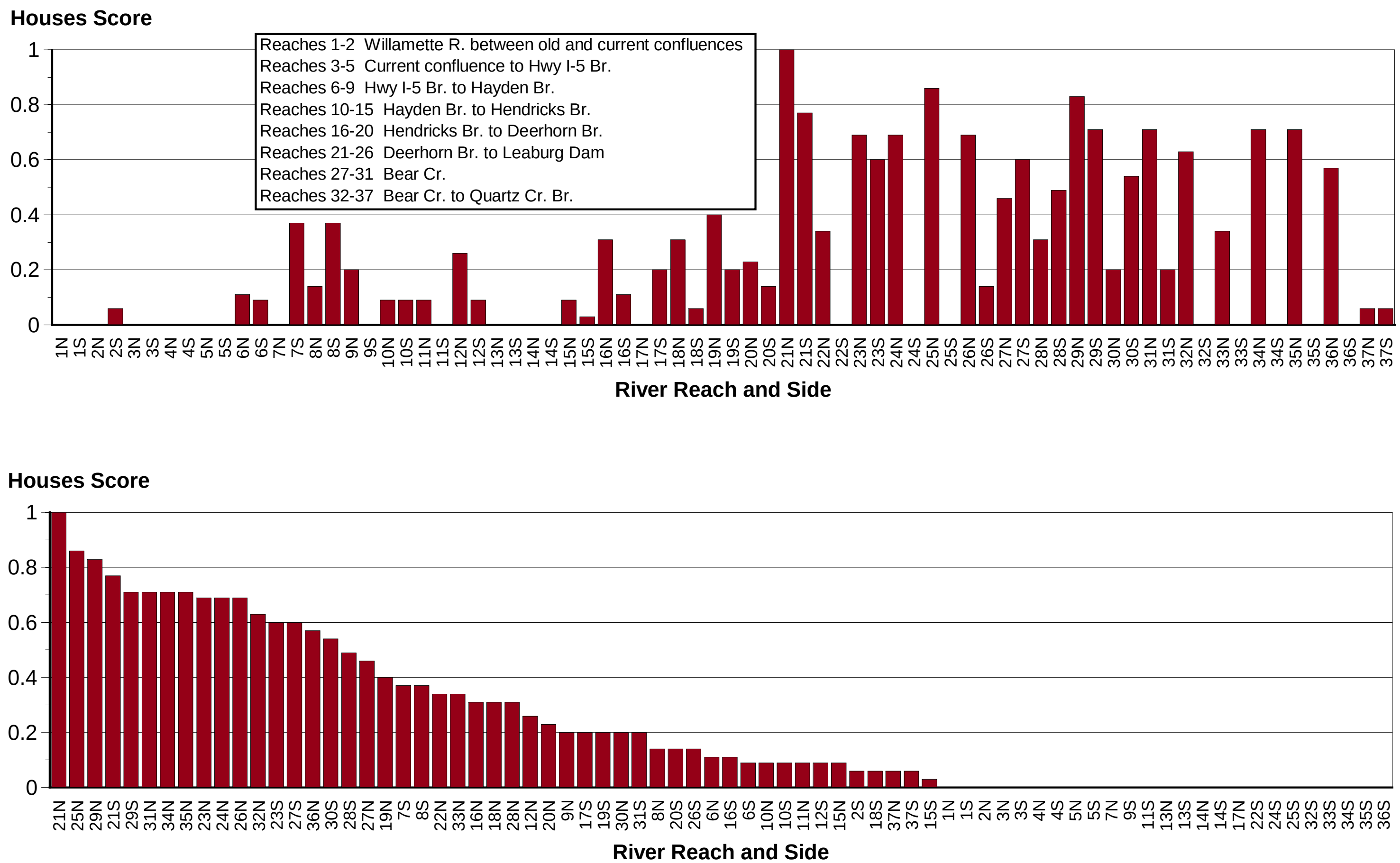


Figure 13. Houses scores (standardized values) for 37 reaches and each side of the river. In the upper graph scores are ordered from downstream to upstream (left to right) and sorted by score in the lower graph.


OREGON
Portland
Salem
Corvallis
Eugene
McKenzie Watershed
0 20 40 60 80 Miles

Figure 1

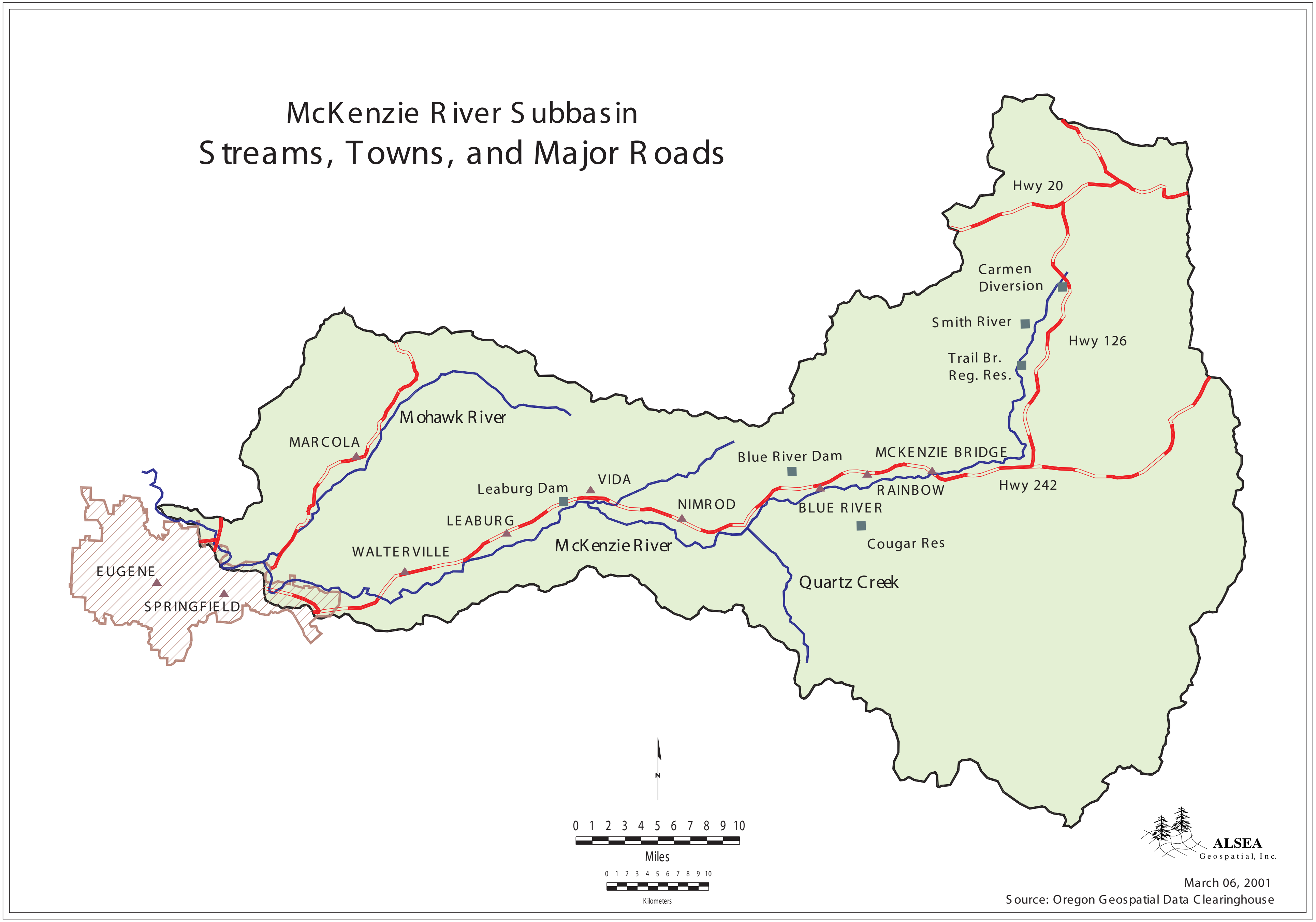
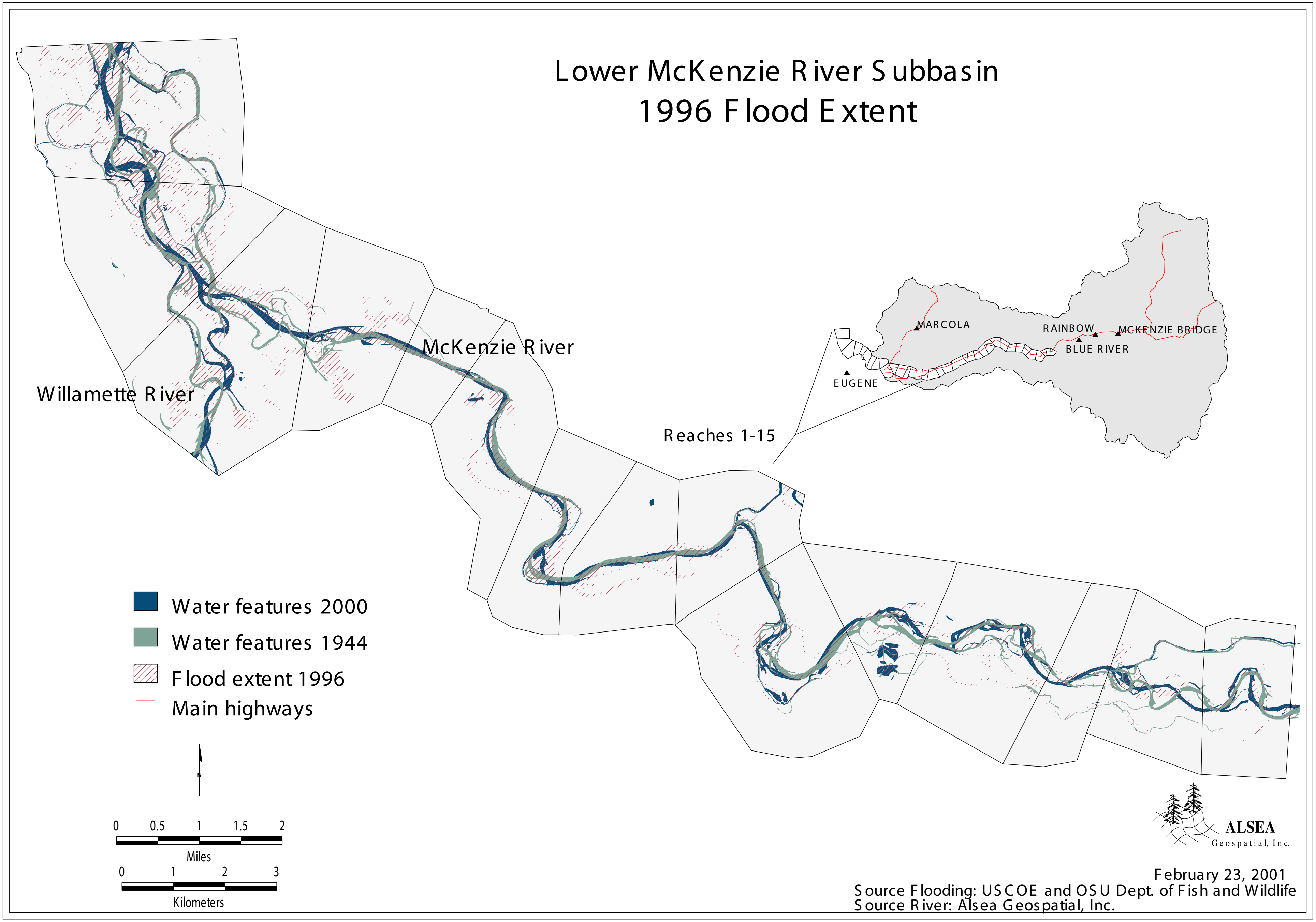

McKenzie River Subbasin
Streams, Towns, and Major Roads
Hwy 20
Carmen
Diversion
Smith River
Hwy 126
Trail Br.
Reg. Res.
Mohawk River
MARCOLA
MCKENZIE BRIDGE
Blue River Dam
VIDA
Leaburg Dam
RAINBOW
Hwy 242
NIMROD
BLUE RIVER
LEABURG
Cougar Res
WALTERVILLE
McKenzie River
EUGENE
Quartz Creek
SPRINGFIELD
N
0 1 2 3 4 5 6 7 8 9 10
Miles
0 1 2 3 4 5 6 7 8 9 10
Kilometers
ALSEA
Geospatial, Inc.
March 06, 2001
Source: Oregon Geospatial Data Clearinghouse

Figure 2



Lower McKenzie River Subbasin
1996 Flood Extent
McKenzie River
Willamette River
Reaches 1-15
MARCOLA
RAINBOW
MCKENZIE BRIDGE
BLUE RIVER
EUGENE
Water features 2000
Water features 1944
Flood extent 1996
Main highways
0 0.5 1 1.5 2
Miles
0 1 2 3
Kilometers
ALSEA
Geospatial, Inc.
February 23, 2001
Source Flooding: USCOE and OSU Dept. of Fish and Wildlife
Source River: Alsea Geospatial, Inc.

Figure 3

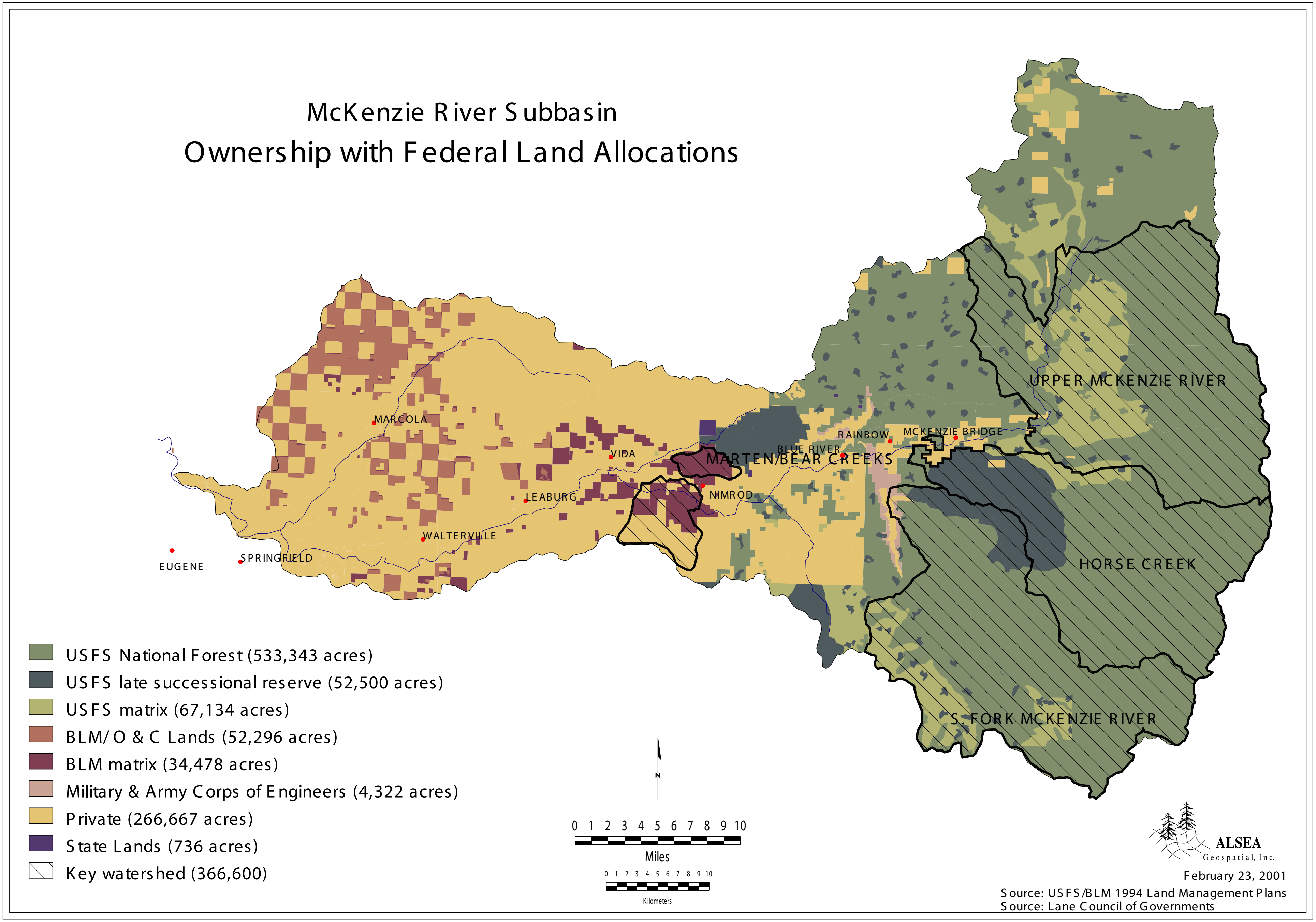
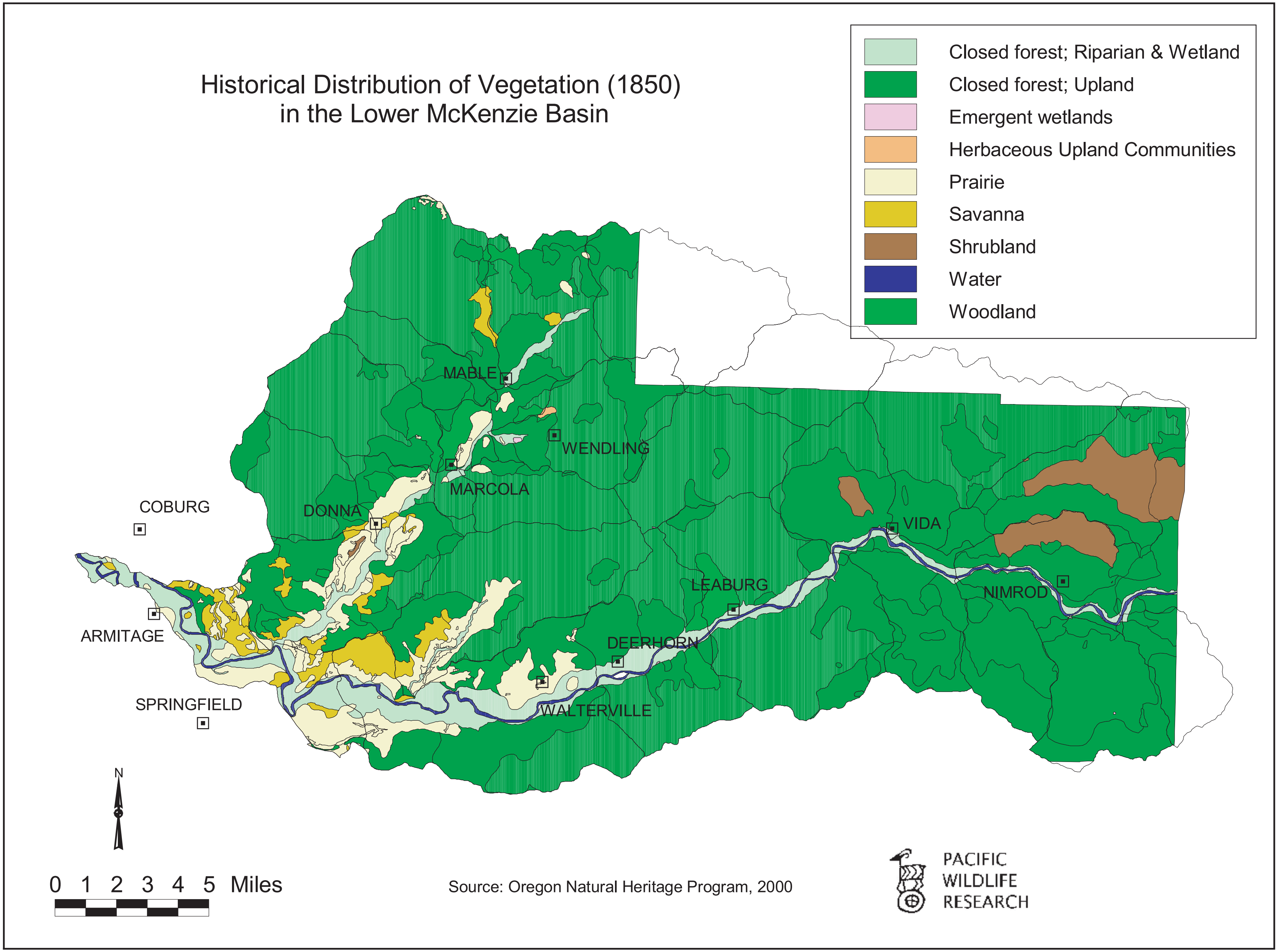

McKenzie River Subbasin
Ownership with Federal Land Allocations
UPPER MCKENZIE RIVER
MARTEN/BEAR CREEKS
HORSE CREEK
S. FORK MCKENZIE RIVER
MARCOLA
VIDA
LEABURG
WALTERVILLE
SPRINGFIELD
EUGENE
NIMROD
BLUE RIVER
RAINBOW
MCKENZIE BRIDGE
USFS National Forest (533,343 acres)
USFS late successional reserve (52,500 acres)
USFS matrix (67,134 acres)
BLM/O & C Lands (52,296 acres)
BLM matrix (34,478 acres)
Military & Army Corps of Engineers (4,322 acres)
Private (266,667 acres)
State Lands (736 acres)
Key watershed (366,600)
N
0 1 2 3 4 5 6 7 8 9 10
Miles
0 1 2 3 4 5 6 7 8 9 10
Kilometers
ALSEA
Geospatial, Inc.
February 23, 2001
Source: USFS/BLM 1994 Land Management Plans
Source: Lane Council of Governments

Figure 4



Historical Distribution of Vegetation (1850)
in the Lower McKenzie Basin
Closed forest; Riparian & Wetland
Closed forest; Upland
Emergent wetlands
Herbaceous Upland Communities
Prairie
Savanna
Shrubland
Water
Woodland
MABLE
WENDLING
MARCOLA
COBURG
DONNA
VIDA
LEABURG
NIMROD
ARMITAGE
DEERHORN
WALTERVILLE
SPRINGFIELD
N
0 1 2 3 4 5 Miles
Source: Oregon Natural Heritage Program, 2000
PACIFIC
WILDLIFE
RESEARCH

Figure 5

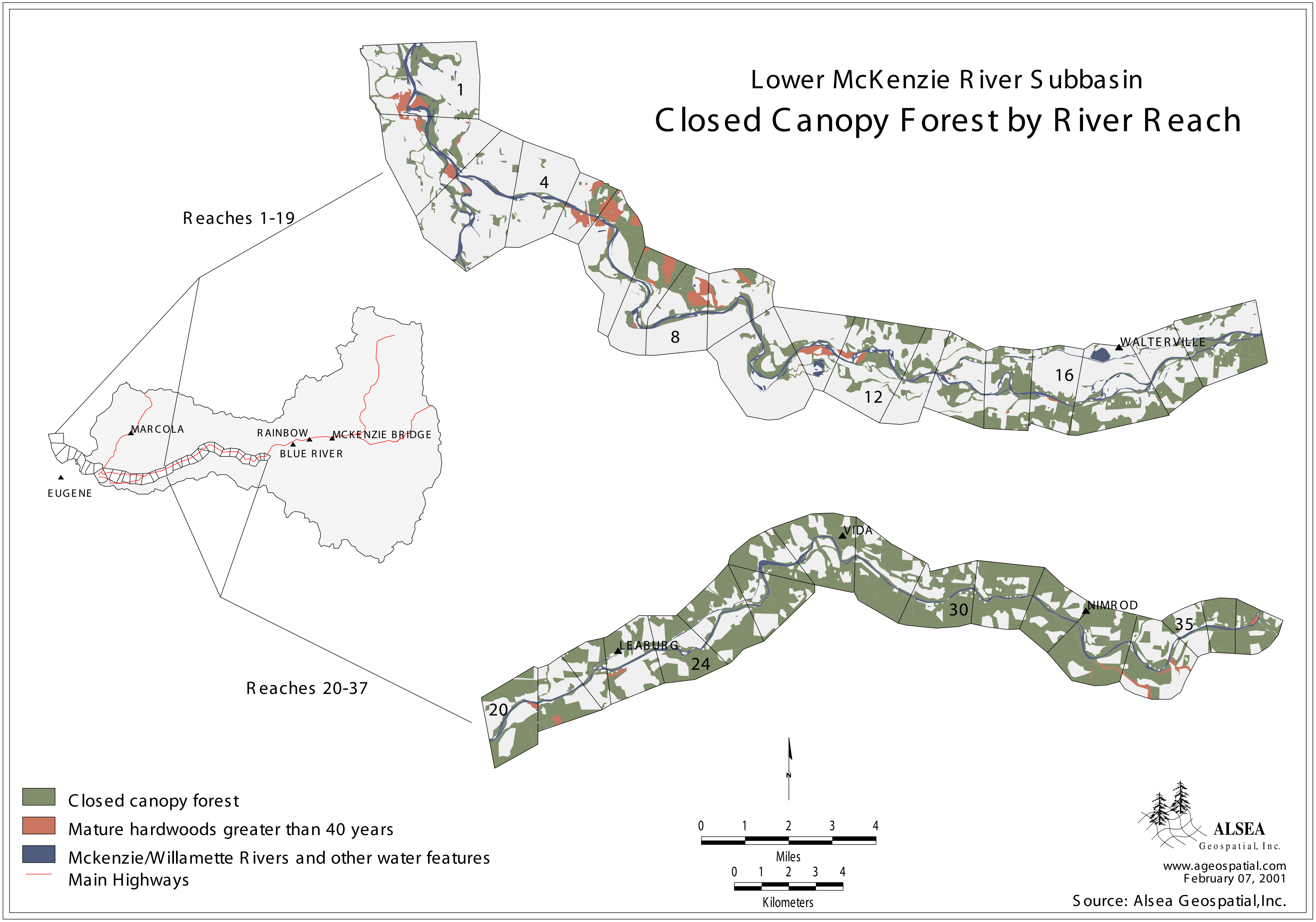

Lower McKenzie River Subbasin
Closed Canopy Forest by River Reach
Reaches 1-19
Reaches 20-37
1
4
8
12
16
20
24
30
35
WALTERVILLE
LEABURG
VIDA
NIMROD
MARCOLA
RAINBOW
MCKENZIE BRIDGE
BLUE RIVER
EUGENE
Closed canopy forest
Mature hardwoods greater than 40 years
Mckenzie/Willamette Rivers and other water features
Main Highways
0 1 2 3 4
Miles
0 1 2 3 4
Kilometers
ALSEA
Geospatial, Inc.
www.ageospatial.com
February 07, 2001
Source: Alsea Geospatial,Inc.

Figure 6

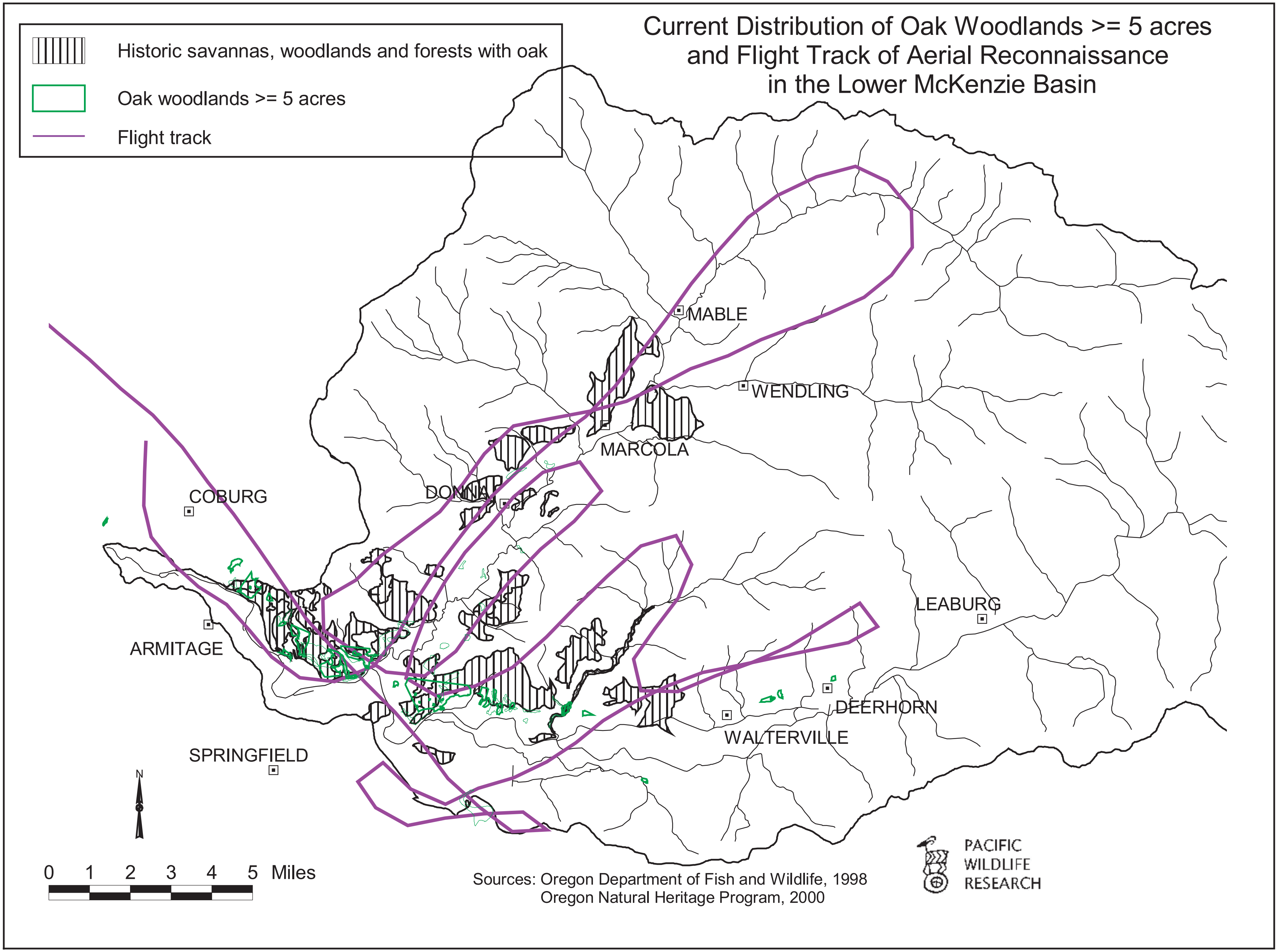

Current Distribution of Oak Woodlands >= 5 acres
and Flight Track of Aerial Reconnaissance
in the Lower McKenzie Basin
Historic savannas, woodlands and forests with oak
Oak woodlands >= 5 acres
Flight track
MABLE
WENDLING
MARCOLA
DONNA
COBURG
ARMITAGE
LEABURG
DEERHORN
WALTERVILLE
SPRINGFIELD
N
0 1 2 3 4 5 Miles
Sources: Oregon Department of Fish and Wildlife, 1998
Oregon Natural Heritage Program, 2000
PACIFIC
WILDLIFE
RESEARCH

Figure 7

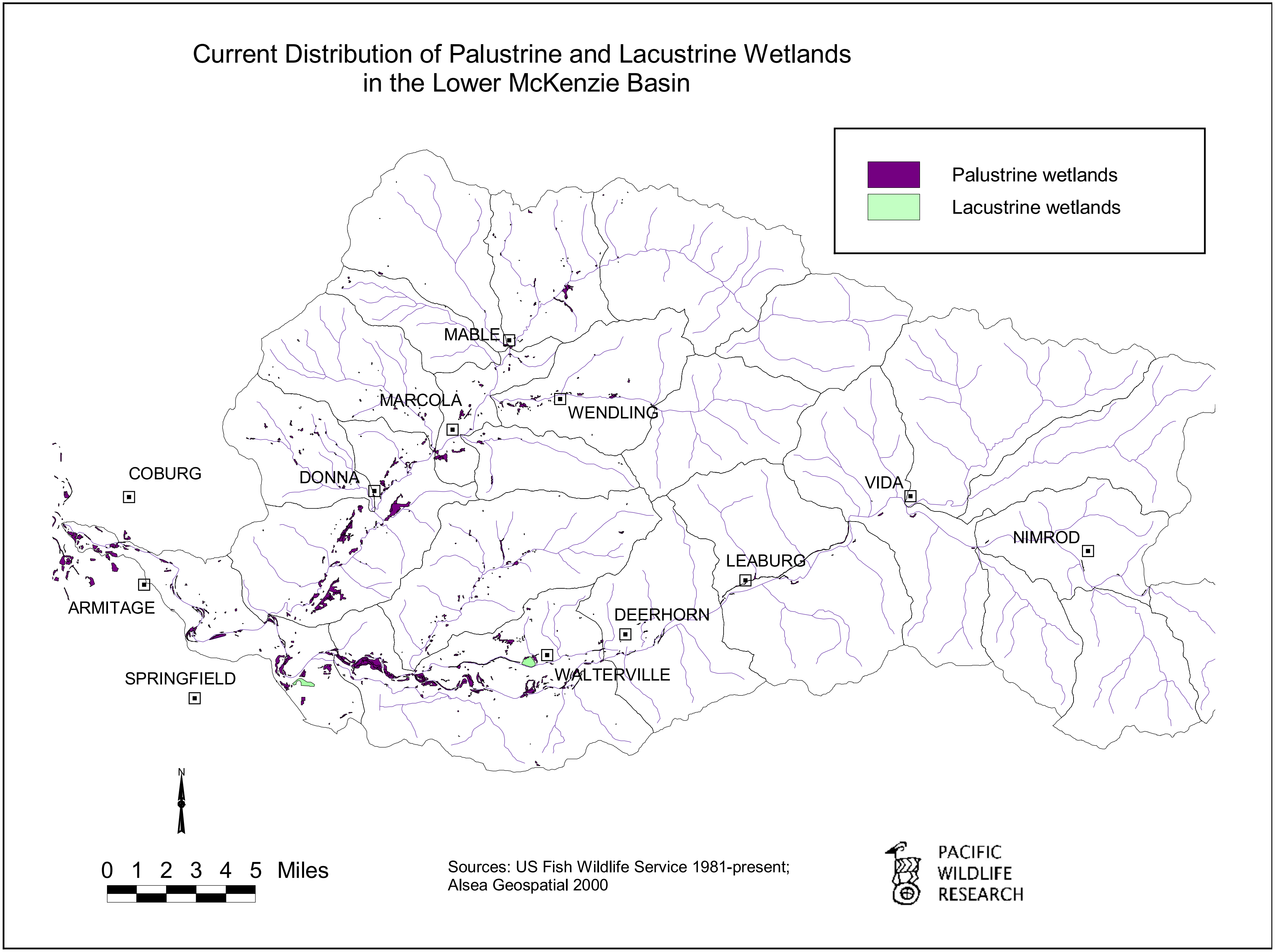

Current Distribution of Palustrine and Lacustrine Wetlands
in the Lower McKenzie Basin
Palustrine wetlands
Lacustrine wetlands
MABLE
MARCOLA
WENDLING
COBURG
DONNA
VIDA
NIMROD
LEABURG
ARMITAGE
DEERHORN
WALTERVILLE
SPRINGFIELD
N
0 1 2 3 4 5 Miles
Sources: US Fish Wildlife Service 1981-present;
Alsea Geospatial 2000
PACIFIC
WILDLIFE
RESEARCH

Figure 8

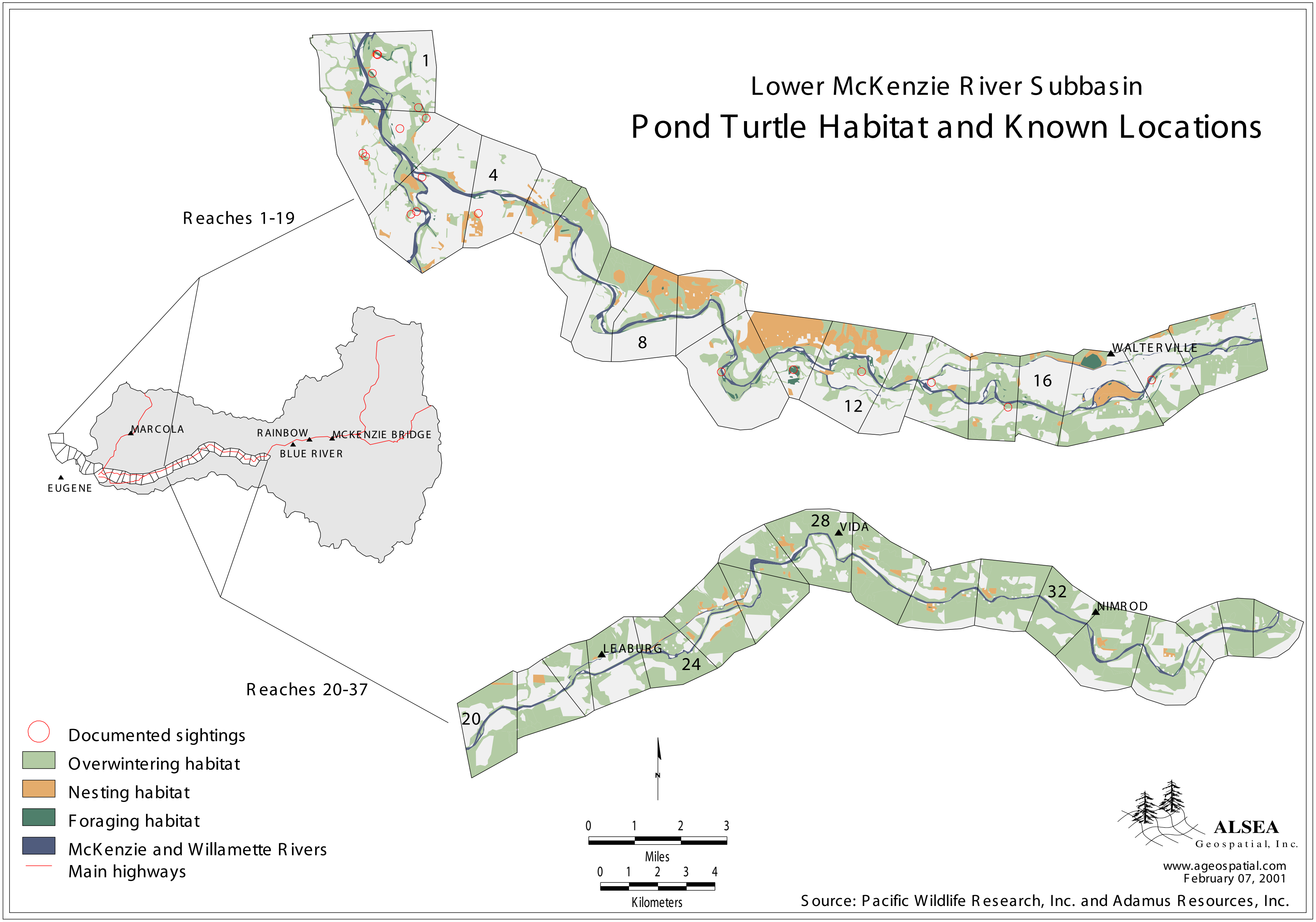

Lower McKenzie River Subbasin
Pond Turtle Habitat and Known Locations
Reaches 1-19
Reaches 20-37
1
4
8
12
16
20
24
28
32
WALTERVILLE
VIDA
LEABURG
NIMROD
MARCOLA
RAINBOW
MCKENZIE BRIDGE
BLUE RIVER
EUGENE
Documented sightings
Overwintering habitat
Nesting habitat
Foraging habitat
McKenzie and Willamette Rivers
Main highways
0 1 2 3
Miles
0 1 2 3 4
Kilometers
N
ALSEA
Geospatial, Inc.
www.ageospatial.com
February 07, 2001
Source: Pacific Wildlife Research, Inc. and Adamus Resources, Inc.

Figure 9

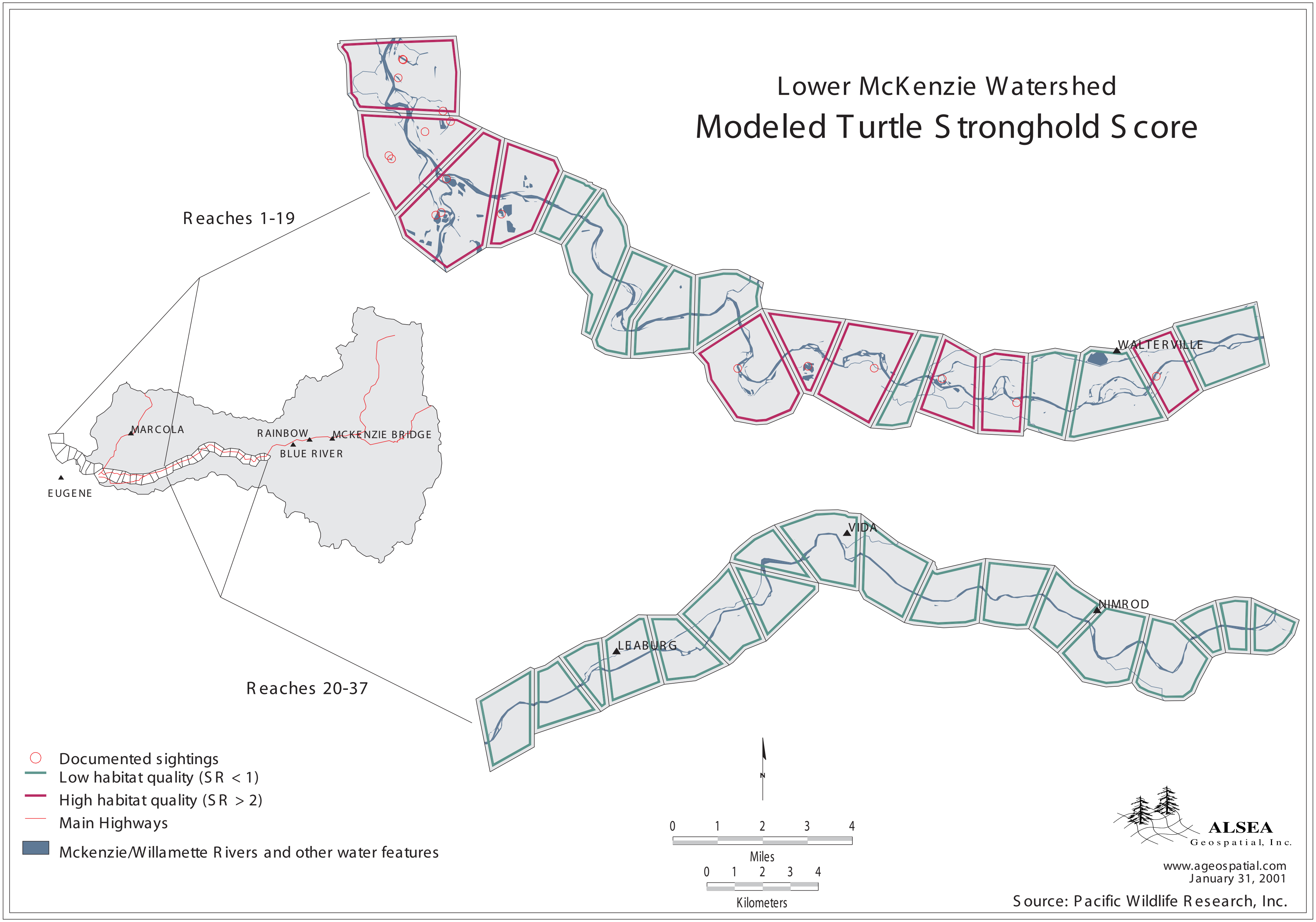
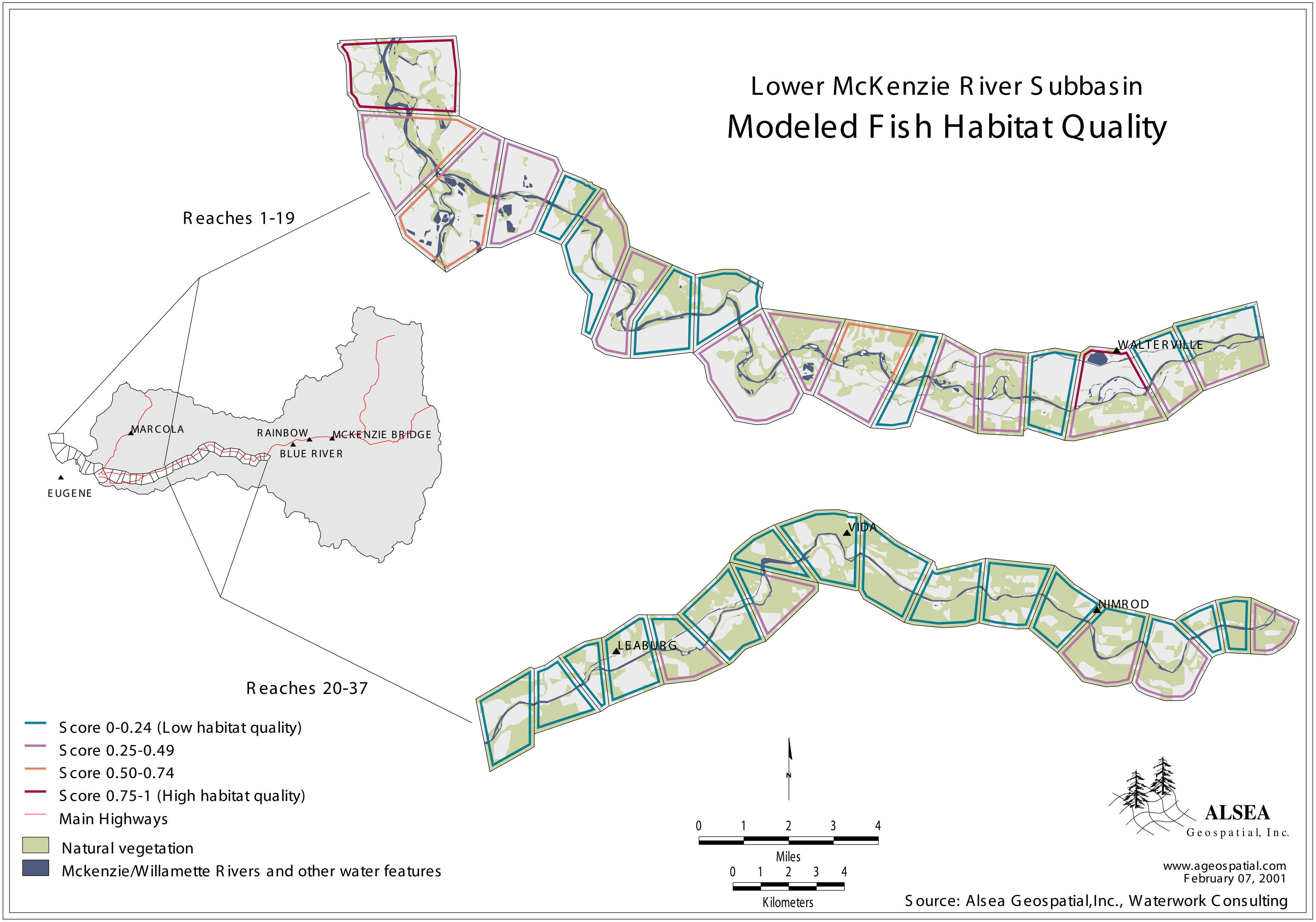

Lower McKenzie Watershed
Modeled Turtle Stronghold Score
Reaches 1-19
Reaches 20-37
MARCOLA
RAINBOW
MCKENZIE BRIDGE
BLUE RIVER
EUGENE
WALTERVILLE
VIDA
NIMROD
LEABURG
Documented sightings
Low habitat quality (SR < 1)
High habitat quality (SR > 2)
Main Highways
Mckenzie/Willamette Rivers and other water features
0 1 2 3 4
Miles
0 1 2 3 4
Kilometers
N
ALSEA
Geospatial, Inc.
www.ageospatial.com
January 31, 2001
Source: Pacific Wildlife Research, Inc.

Figure 10



Lower McKenzie River Subbasin
Modeled Fish Habitat Quality
Reaches 1-19
Reaches 20-37
MARCOLA
RAINBOW
MCKENZIE BRIDGE
BLUE RIVER
EUGENE
WALTERVILLE
VIDA
NIMROD
LEABURG
Score 0-0.24 (Low habitat quality)
Score 0.25-0.49
Score 0.50-0.74
Score 0.75-1 (High habitat quality)
Main Highways
Natural vegetation
Mckenzie/Willamette Rivers and other water features
0 1 2 3 4
Miles
0 1 2 3 4
Kilometers
N
ALSEA
Geospatial, Inc.
www.ageospatial.com
February 07, 2001
Source: Alsea Geospatial,Inc., Waterwork Consulting

Figure 11

xii

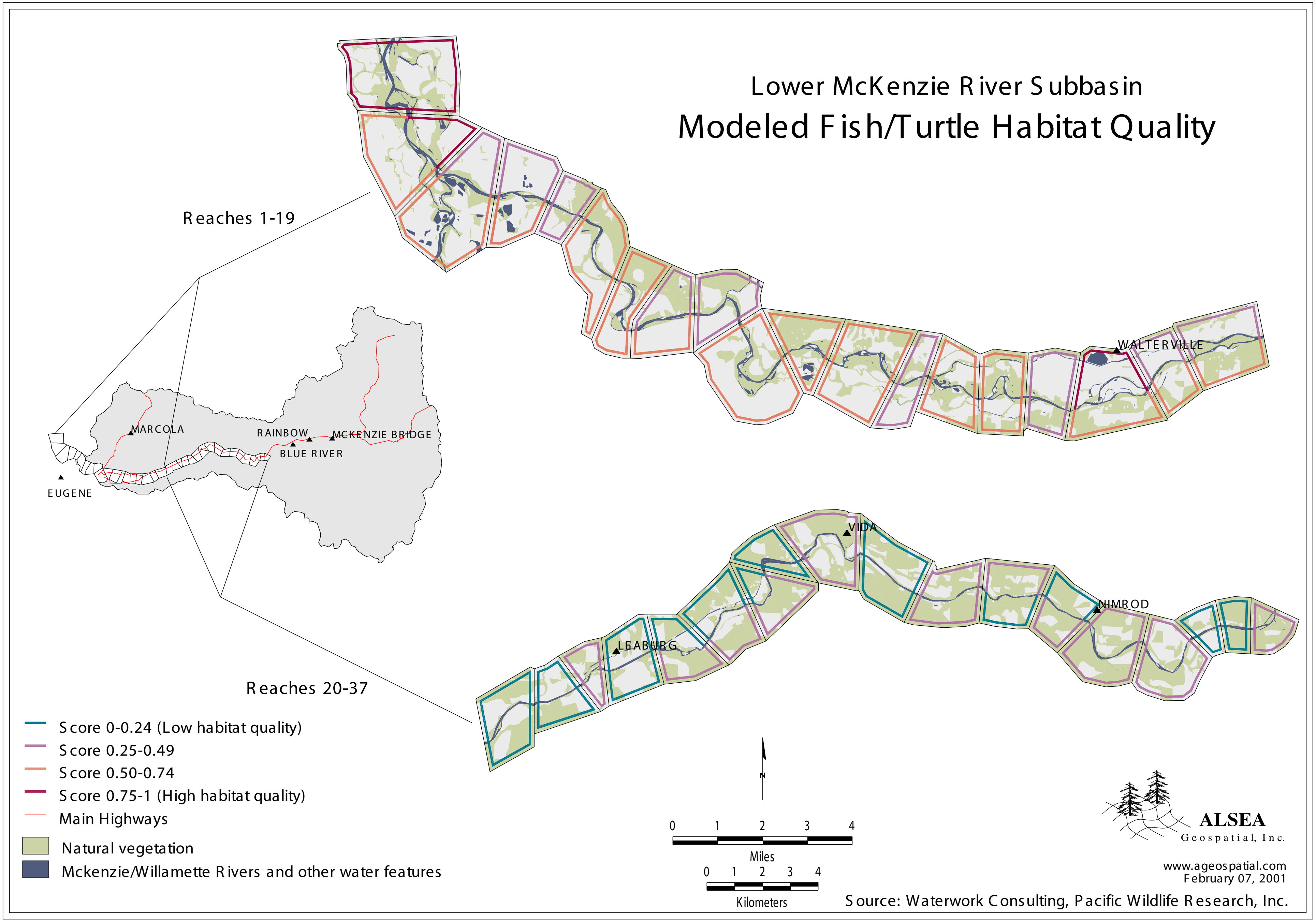


Figure 12


McKenzie River 1944 and 2000
Channel and Vegetation Characteristics by Reach
Willamette River to Quartz Creek
1944
2000
VIDA
NIMROD
LEABURG
WALTERVILLE
1
5
10
15
20
25
30
35
Hardwood 15-39 years
Hardwood 40-80 years
Hardwood greater than 80 years
Conifer 15-39 years
Conifer 40-80 years
Conifer greater than 80 years
Mixed conifer and oak 15-39 years
Mixed conifer and oak 40-80 years
Mixed conifer and hardwood 15-39 years
Mixed conifer and hardwood 40-80 years
Mixed Conifer and hardwood greater than 80 years
Clear cut
Farm field
Grassland/Brush
Orchard
Urban residential
Rural residential
Business/Industrial
Golf course
Major roads/Large parking lots
Bare area at gravel operation
Bare, active gravel pit
Gravel bars
Pond in gravel mining area not normally connected to river
Pond in gravel mining area normally connected to river
Main river channel, alcoves, side channels and natural ponds
Main channel thalweg
1-37 Reach number
0 1 2 3 4 5
Miles
0 1 2 3 4 5
Kilometers
www.ageospatial.com
February 07, 2001
/u2/mckz/wa/maps/riv44_00sh.aml

Figure 13

McKenzie River Subbasin

Geomorphology of Study Area with Lithology of Basin

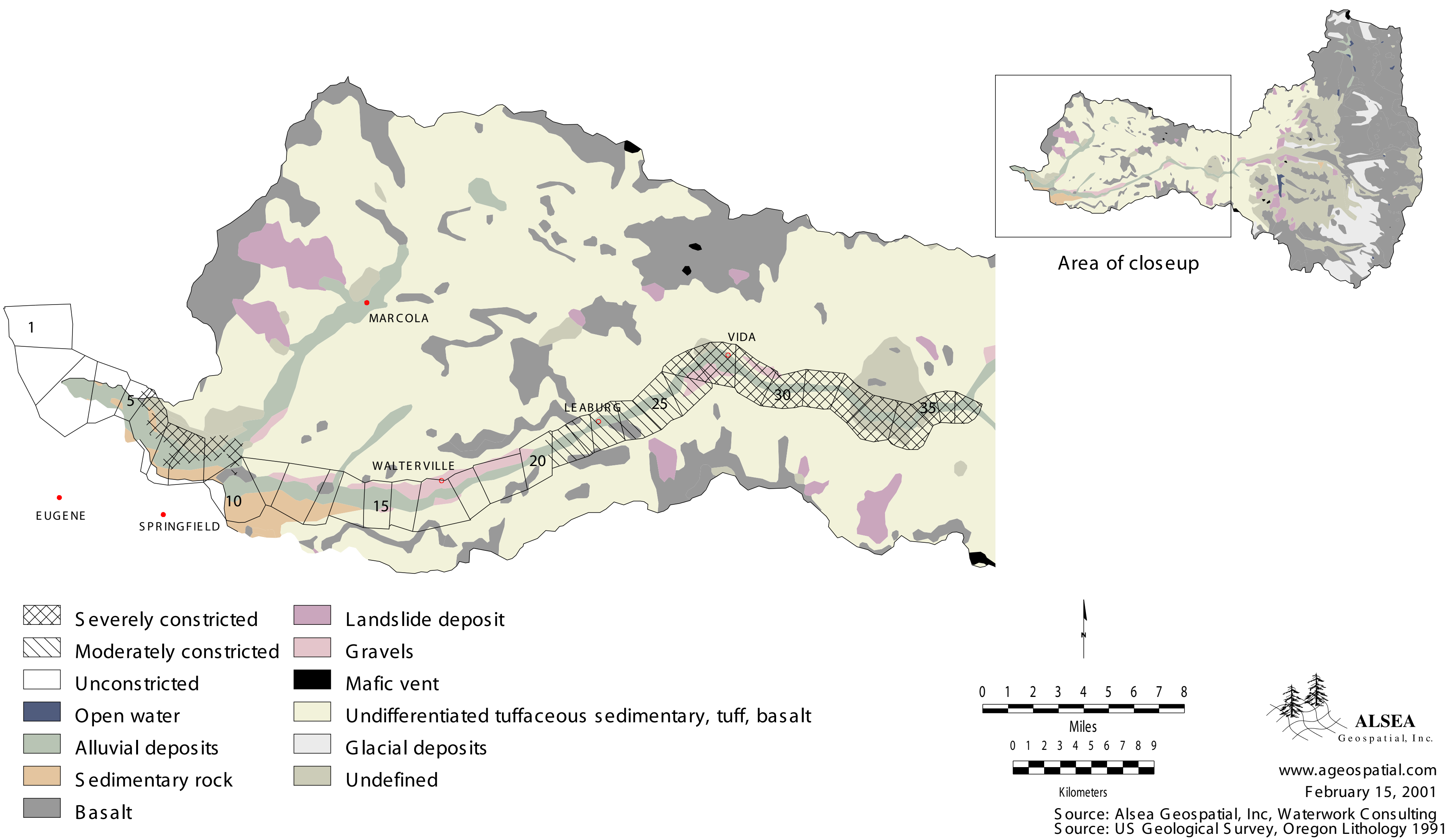


Figure 14

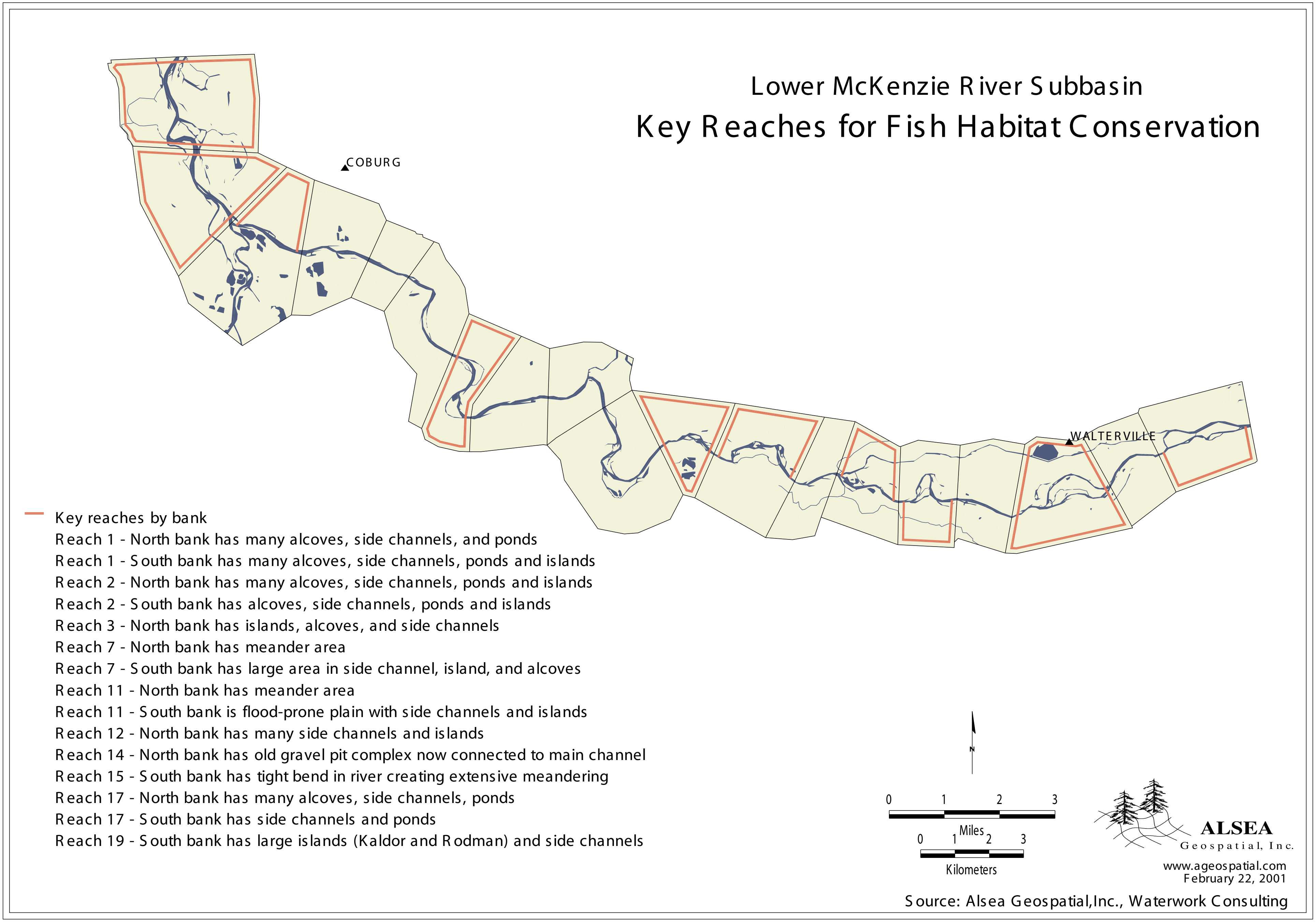

Lower McKenzie River Subbasin
Key Reaches for Fish Habitat Conservation
COBURG
WALTERVILLE
Key reaches by bank
Reach 1 - North bank has many alcoves, side channels, and ponds
Reach 1 - South bank has many alcoves, side channels, ponds and islands
Reach 2 - North bank has many alcoves, side channels, ponds and islands
Reach 2 - South bank has alcoves, side channels, ponds and islands
Reach 3 - North bank has islands, alcoves, and side channels
Reach 7 - North bank has meander area
Reach 7 - South bank has large area in side channel, island, and alcoves
Reach 11 - North bank has meander area
Reach 11 - South bank is flood-prone plain with side channels and islands
Reach 12 - North bank has many side channels and islands
Reach 14 - North bank has old gravel pit complex now connected to main channel
Reach 15 - South bank has tight bend in river creating extensive meandering
Reach 17 - North bank has many alcoves, side channels, ponds
Reach 17 - South bank has side channels and ponds
Reach 19 - South bank has large islands (Kaldor and Rodman) and side channels
N
0 1 2 3
Miles
0 1 2 3
Kilometers
ALSEA
Geospatial, Inc.
www.ageospatial.com
February 22, 2001
Source: Alsea Geospatial,Inc., Waterwork Consulting

Figure 15

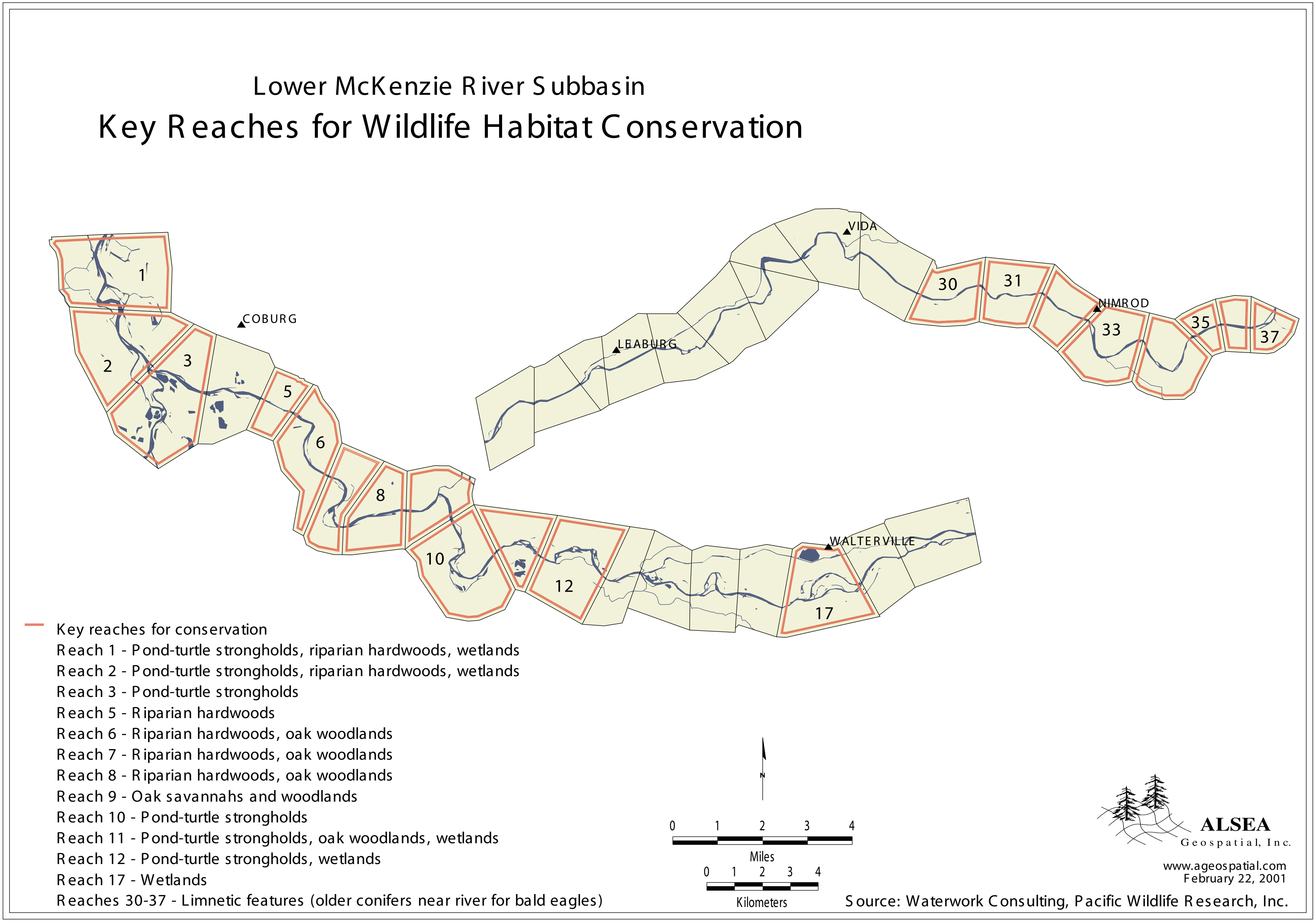
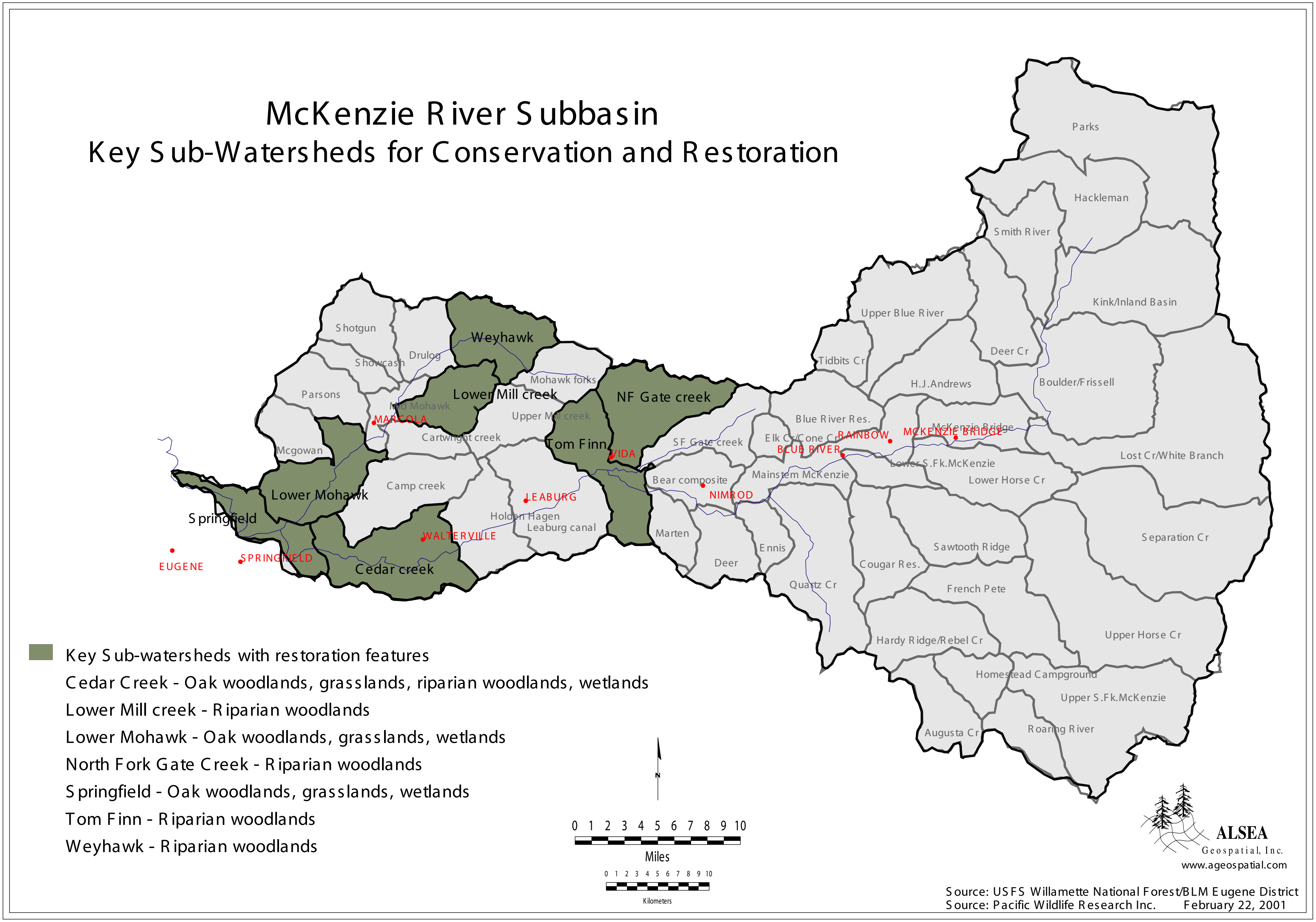

Lower McKenzie River Subbasin
Key Reaches for Wildlife Habitat Conservation
COBURG
LEABURG
VIDA
NIMROD
WALTERVILLE
1
2
3
5
6
8
10
12
17
30
31
33
35
37
Key reaches for conservation
Reach 1 - Pond-turtle strongholds, riparian hardwoods, wetlands
Reach 2 - Pond-turtle strongholds, riparian hardwoods, wetlands
Reach 3 - Pond-turtle strongholds
Reach 5 - Riparian hardwoods
Reach 6 - Riparian hardwoods, oak woodlands
Reach 7 - Riparian hardwoods, oak woodlands
Reach 8 - Riparian hardwoods, oak woodlands
Reach 9 - Oak savannahs and woodlands
Reach 10 - Pond-turtle strongholds
Reach 11 - Pond-turtle strongholds, oak woodlands, wetlands
Reach 12 - Pond-turtle strongholds, wetlands
Reach 17 - Wetlands
Reaches 30-37 - Limnetic features (older conifers near river for bald eagles)
0 1 2 3 4
Miles
0 1 2 3 4
Kilometers
ALSEA
Geospatial, Inc.
www.ageospatial.com
February 22, 2001
Source: Waterwork Consulting, Pacific Wildlife Research, Inc.

Figure 16



McKenzie River Subbasin
Key Sub-Watersheds for Conservation and Restoration
Parks
Hackleman
Smith River
Kink/Inland Basin
Upper Blue River
Deer Cr
Tidbits Cr
H.J.Andrews
Boulder/Frissell
Shotgun
Showcash
Drulog
Weyhawk
Mohawk forks
Lower Mill creek
NF Gate creek
Parsons
Mid Mohawk
MARCOLA
Upper Mill creek
Cartwright creek
Tom Finn
VIDA
SF Gate creek
Blue River Res.
Elk Cr/Cone Cr
RAINBOW
MCKENZIE BRIDGE
McKenzie Bridge
BLUE RIVER
Lower S.Fk.McKenzie
Lost Cr/White Branch
Mcgowan
Camp creek
Bear composite
Mainstem McKenzie
NIMROD
Lower Horse Cr
Lower Mohawk
LEABURG
Holden Hagen
Leaburg canal
Springfield
WALTERVILLE
Marten
Ennis
Deer
Sawtooth Ridge
Separation Cr
EUGENE
SPRINGFIELD
Cedar creek
Cougar Res.
Quartz Cr
French Pete
Hardy Ridge/Rebel Cr
Upper Horse Cr
Homestead Campground
Upper S.Fk.McKenzie
Augusta Cr
Roaring River
Key Sub-watersheds with restoration features
Cedar Creek - Oak woodlands, grasslands, riparian woodlands, wetlands
Lower Mill creek - Riparian woodlands
Lower Mohawk - Oak woodlands, grasslands, wetlands
North Fork Gate Creek - Riparian woodlands
Springfield - Oak woodlands, grasslands, wetlands
Tom Finn - Riparian woodlands
Weyhawk - Riparian woodlands
N
0 1 2 3 4 5 6 7 8 9 10
Miles
0 1 2 3 4 5 6 7 8 9 10
Kilometers
ALSEA
Geospatial, Inc.
www.ageospatial.com
Source: USFS Willamette National Forest/BLM Eugene District
Source: Pacific Wildlife Research Inc. February 22, 2001

Figure 17